Hercules III User Manual

High Integration EBX SBC with Data Acquisition & DC Power Supply

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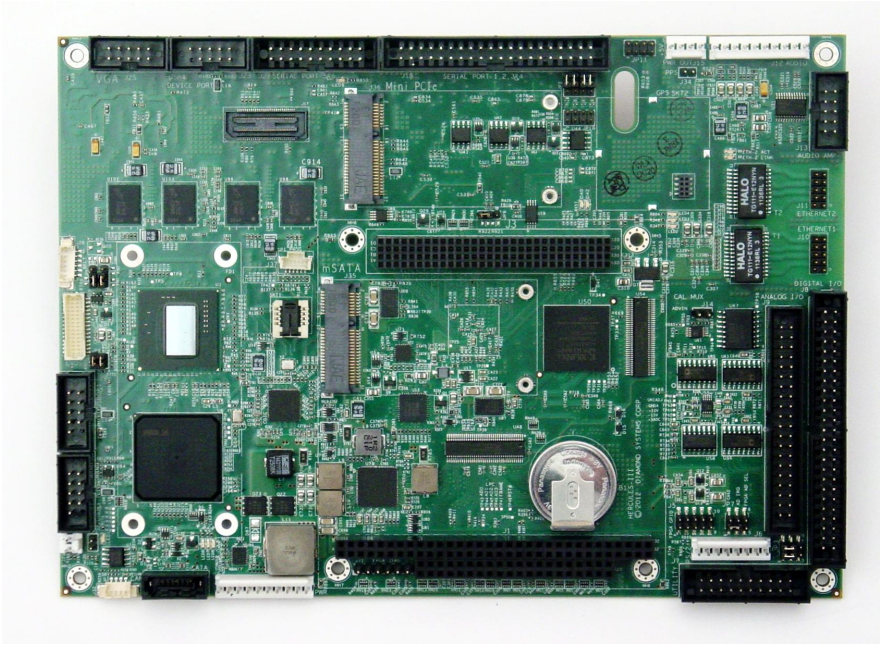

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1. IMPORTANT SAFE HANDLING INFORMATION

WARNING!

ESD-Sensitive Electronic Equipment

Observe ESD-safe handling procedures when working with this product.

Always use this product in a properly grounded work area and wear appropriate ESD-preventive clothing and/or accessories.

Always store this product in ESD-protective packaging when not in use.

Safe Handling Precautions

The Helios board contains a high number of I/O connectors with connection to sensitive electronic components. This creates many opportunities for accidental damage during handling, installation and connection to other equipment. The list here describes common causes of failure found on boards returned to Diamond Systems for repair. This information is provided as a source of advice to help you prevent damaging your Diamond (or any vendor's) embedded computer boards.

ESD damage – This type of damage is usually almost impossible to detect, because there is no visual sign of failure or damage. The symptom is that the board eventually simply stops working, because some component becomes defective. Usually the failure can be identified and the chip can be replaced.

To prevent ESD damage, always follow proper ESD-prevention practices when handling computer boards.

Damage during handling or storage – On some boards we have noticed physical damage from mishandling. A common observation is that a screwdriver slipped while installing the board, causing a gouge in the PCB surface and cutting signal traces or damaging components.

Another common observation is damaged board corners, indicating the board was dropped. This may or may not cause damage to the circuitry, depending on what is near the corner. Most of our boards are designed with at least 25 mils clearance between the board edge and any component pad, and ground / power planes are at least 20 mils from the edge to avoid possible shorting from this type of damage. However these design rules are not sufficient to prevent damage in all situations.

A third cause of failure is when a metal screwdriver tip slips, or a screw drops onto the board while it is powered on, causing a short between a power pin and a signal pin on a component. This can cause overvoltage / power supply problems described below. To avoid this type of failure, only perform assembly operations when the system is powered off.

Sometimes boards are stored in racks with slots that grip the edge of the board. This is a common practice for board manufacturers. However our boards are generally very dense, and if the board has components very close to the board edge, they can be damaged or even knocked off the board when the board tilts back in the rack. Diamond recommends that all our boards be stored only in individual ESD-safe packaging. If multiple boards are stored together, they should be contained in bins with dividers between boards. Do not pile boards on top of each other or cram too many boards into a small location. This can cause damage to connector pins or fragile components.

Power supply wired backwards – Our power supplies and boards are not designed to withstand a reverse power supply connection. This will destroy each IC that is connected to the power supply (i.e. almost all ICs). In this case, the board will most likely cannot be repaired and must be replaced. A chip destroyed by reverse power or by excessive power will often have a visible hole on the top or show some deformation on the top surface due to vaporization inside the package. Check twice before applying power!

Board not installed properly in PC/104 stack – A common error is to install a PC/104 board accidentally shifted by 1 row or 1 column. If the board is installed incorrectly, it is possible for power and ground signals on the bus to make contact with the wrong pins on the board, which can damage the board. For example, this can damage components attached to the data bus, because it puts the ±12V power supply lines directly on data bus lines.

Overvoltage on analog input – If a voltage applied to an analog input exceeds the design specification of the board, the input multiplexor and/or parts behind it can be damaged. Most of our boards will withstand an erroneous connection of up to ±35V on the analog inputs, even when the board is powered off, but not all boards, and not in all conditions.

Overvoltage on analog output – If an analog output is accidentally connected to another output signal or a power supply voltage, the output can be damaged. On most of our boards, a short circuit to ground on an analog output will not cause trouble.

Overvoltage on digital I/O line – If a digital I/O signal is connected to a voltage above the maximum specified voltage, the digital circuitry can be damaged. On most of our boards the acceptable range of voltages connected to digital I/O signals is 0-5V, and they can withstand about 0.5V beyond that (-0.5 to 5.5V) before being damaged. However logic signals at 12V and even 24V are common, and if one of these is connected to a 5V logic chip, the chip will be damaged, and the damage could even extend past that chip to others in the circuit.

Bent connector pins – This type of problem is often only a cosmetic issue and is easily fixed by bending the pins back to their proper shape one at a time with needle-nose pliers. The most common cause of bent connector pins is when a PC/104 board is pulled off the stack by rocking it back and forth left to right, from one end of the connector to the other. As the board is rocked back and forth it pulls out suddenly, and the pins at the end get bent significantly. The same situation can occur when pulling a ribbon cable off of a pin header. If the pins are bent too severely, bending them back can cause them to weaken unacceptably or even break, and the connector must be replaced.

2. INTRODUCTION

Hercules III is an embedded single-board computer (SBC) in the EBX small form factor that integrates a complete embedded PC, data acquisition circuitry, and DC power supply into a single board.

The Hercules III SBC is based on an Intel E680T CPU with onboard central processing, memory and memory management devices and I/O management for specific functions. The Hercules III SBC includes the following additional features.

- Communicates externally over the ISA bus, PCI bus, and I/O ports
- Generates on-board RGB video for CRT display systems
- Contains LVDS formatting to drive a flat panel
- Is powered from an external +7-40VDC wide voltage input

One standard model of Hercules III with data acquisition is available as shown in the following table. Three other models are available with a minimum order of 50 units.

Model	*Processor Speed*	*RAM Size*	*Data Acquisition*	*Availability*
HRCE1600A-1G	1.6GHz	1GB	Yes	Standard model
HRCE1600D-1G	1.6GHz	1GB	DIO only	MOQ of 50
HRCE1600A-2G	1.6GHz	2GB	Yes	MOQ of 50
HRCE1600D-2G	1.6GHz	2GB	DIO only	MOQ of 50

The Hercules III SBC brings the ISA and PCI buses out to an expansion connector to mate with add-on boards. Diamond Systems manufactures a wide variety of compatible PC/104-*Plus* add-on boards for analog I/O, digital I/O, counter/timer functions, serial ports and power supplies.

2.1 Functions

The Hercules III board includes the following key system and data acquisition features. The functions listed below are applicable for all models.

- 1.6GHz Intel Atom E680T “Tunnel Creek” processor (Queensbay platform)
- 1GB or 2GB SDRAM soldered on-board
- 2 Gigabit Ethernet ports on pin header, with on-board magnetics
- 5 USB 2.0 ports
- 1 USB 2.0 device port
- 4 RS-232/422/485 serial ports
- 2 fixed RS-232 serial ports
- LVDS flat panel interface
- VGA or LVDS interface up to 1600 x 1200 maximum
- 1 SATA port
- 1 mSATA disk module interface
- 1 CANbus 2.0 port
- 40 digital I/O lines with programmable direction
- HD Audio CODEC
- +7V to +40V DC/DC wide range power supply with 35W available for add-on accessories or modules

2.2 Data Acquisition

The functions listed below are applicable to the data acquisition versions only.

- 32 channel 16-bit A/D, 250KHz maximum sample rate
- Single-ended or differential mode
- Programmable input ranges +/-10V, +/-5V, +/-2.5V, +/-1.25V, 0-10V, 0-5V, 0-2.5V
- Interrupt-based sampling with 2048-sample programmable FIFO
- 4 12-bit D/A channels
- Output ranges: +/-10V, +/-5V, 0-10V, 0-5V
- 4 pulse width modulation circuits
- Watchdog timer
- 1 24-bit and 1 16-bit counter/timer for A/D sample rate control, event counting, and programmable interrupts
- Auto-calibration with Universal Driver software support

2.3 Expansion Options

- mSATA flashdisk mounting capability
- PC/104-*Plus* expansion connector
- PCIe MiniCard and GPS receiver sockets

2.4 Operating System Support

- Windows Embedded Standard 7
- Linux 2.6
- Windows CE 6.0 R3

2.5 Mechanical, Electrical, Environmental

- EBX form factor, 5.75”W x 8.0”H, identical to Hercules II
- Fanless heat sink on top side
- -40°C to +85°C ambient operating temperature without a fan
- MIL-STD-202G shock and vibration compliant
- Power input requirements: +7-40VDC +/- 5%

3. GETTING STARTED

First-time Hercules III SBC users normally receive the product as part of Diamond's Hercules III Development Kit, which provides everything needed to ensure rapid application development. This section of the Hercules III User Manual covers basic hardware setup, power connection, system boot-up, and initial software configuration. After Hercules III is up and running, refer to the later sections of this manual for the detailed hardware and software reference information needed to adapt the product to specific applications.

Important Safe-Handling Information

WARNING: ESD-Sensitive Electronic Equipment!

Observe ESD-safe handling procedures when working with this product.

Always use this product in a properly grounded work area and wear appropriate ESD-preventive clothing and/or accessories.

Always store this product in ESD-protective packaging when not in use.

Please refer to page 5 of this manual ("Important Safe-Handling Information") for further details.

3.1 Introducing the Hercules III Development Kit

The Hercules III Development Kit (DK-HRCE-A-xxx) provides everything required for Hercules III based rapid application development. Development Kits are available with bootable images of Linux, Windows Embedded 7 and Windows CE. The various Development Kits are as follows:

DK-HRCE-A-LNX	Development Kit with bootable Linux operating system
DK-HRCE-A-WE7	Development Kit with bootable Windows Embedded 7 operating system
DK-HRCE-A-WCE	Development Kit with bootable Windows CE 6 operating system

The table on the next page lists the boards, cables, and other items included.

Item	Diamond P/N	Description
1	HRCE1600A-1G	Hercules III SBC, 1.6GHz Atom E680T CPU, 1GB SDRAM, Data Acquisition
2	889210x	16GB mSATA MLC flashdisk with bootable OS pre-loaded (based on the Kit ordered)
3	C-HRCE-KIT	Hercules III Cable Kit
4	PS-12V-01	12V AC Power Adapter
5	7460001	Hercules III Quick Start Guide
6	6710010	Diamond Systems Software and Documentation CD
7	DOC-PKG	Diamond Systems Document Package
8	MTG104	PC/104 Mounting Hardware Kit
9	7492100/7492103	BSP Quickstart guide (based on the Kit ordered)
10	7482100/7482103	BSP User Manual (based on the Kit ordered)

3.1.1 Hercules III Cable Kit

The Hercules III Cable Kit (number C-HRCE-KIT) provides convenient access to most of Hercules III's I/O features. The kit's cable assemblies are identified in the following table.

Number	Quantity	Cable No.	Description	Connects to …
1	1	6981006	Power out cable	J15
2	1	6981011	External battery cable	J20
3	1	6981012	Dual USB cable	J21, J22
4	1	6981015	Power input cable	J33
5	1	6981018	Speaker output cable	J13
6	1	6981022	PS/2 keyboard & mouse cable	J6
7	1	6981024	VGA cable	J25
8	1	6981025	Audio I/O cable	J12
9	2	6981080	Ethernet cable	J10, J11
10	1	6981315	CANbus cable	J32
11	1	8180020	Utility board	
12	1	C-20-18	Utility signals cable	J7
13	1	C-40-18	Analog I/O cable	J9
14	1	C-50-18	Digital I/O cable	J8
15	1	C-DB9M-2	Serial port 5 & 6 cable	J18
16	1	C-DB9M-4	Serial ports 1 -- 4 cable	J27

Note: *On each interface cable, the end of the cable connector that has a red wire going to it should be oriented toward the end of the board connector that is labeled "pin 1" (typically the pin with a square pad on the PCB).*

3.2 System Setup

This section outlines a simple process for preparing Hercules III for first-time operation using the Hercules III Development Kit. Additional details regarding Hercules III's interface functions and connections may be found in Section 6 of this document (Connectors).

3.2.1 Unpacking

Unpack and remove the Hercules III single board computer from its packaging.

3.2.2 Mounting Kit

Install the four standoffs found in the mounting kit (MTG104) into the four PC/104 mounting holes located on the board. This ensures that the board will not touch the surface beneath it, and helps redistribute the force when you push connectors onto the board.

3.2.3 Keyboard and Mouse

Hercules III supports operation using a PS/2-based keyboard and mouse devices. Plug the keyboard and mouse connectors into the appropriate connectors on the Main I/O cable in the Hercules III Cable Kit (cable number 6981022). Connect the end of the cable into connector J16 on Hercules III.

3.2.4 mSATA Flashdisk Socket

Hercules III provides a location for on-board installation of an optional mSATA flashdisk on connector J35. Plug the mSATA flashdisk module in the Development Kit into connector J35 on Hercules III. Remove the screw from the mounting stand-off before installing the flashdisk. Secure the flashdisk to Hercules III with the screw once the flashdisk is installed.

3.2.5 Mass Storage Devices

If desired, connect SATA hard drives to Hercules III by connecting a SATA cable to SATA connector J4 and then to the SATA drive. Hercules III can operate with a combination of SATA and CD-ROM drives, and can boot from either of them.

> ***Caution!*** *Be sure the* PS-12V-01 *AC power adapter is disconnected from its AC power source prior to performing the following step.*

3.2.6 Connecting Power

Connect cable 6981015 to the PS-12V-01 AC power adapter or an ATX power supply. Connect the other end of the 6981015 cable to connector J33 on the Hercules III SBC.

3.2.7 Display

Hercules III provides interfaces for both LVDS flat panel displays and VGA output. Connect the VGA cable, 6981024, between the VGA connector, J25, and a VGA-compatible display.

3.3 Booting the System

Power-up the VGA video monitor. Then plug the PS-12V-01 AC power adapter to an AC outlet. Hercules III should begin its boot-up sequence immediately, as evidenced by BIOS messages on the connected VGA display. You can run the BIOS Setup utility and proceed to install an operating system on the boot drive just as you would on a normal desktop PC.

3.3.1 BIOS Setup

Hercules III's BIOS provides a wide range of configuration options. When you power up Hercules III for the first time, you should immediately enter the BIOS "Setup" utility in order to adjust BIOS settings to match your system's peripheral devices and other requirements, and to configure various other hardware and software parameters.

Options configurable via Setup typically include:

- Number and type of mass storage devices
- Boot device priority (default is mSATA)
- Video display type and resolution
- USB, SATA, serial, and parallel interface modes and protocols
- PCI and PnP configuration
- Power management setup
- Automatic power-up after LAN connection, RTC alarm, power resumption, etc.
- System monitoring and security functions

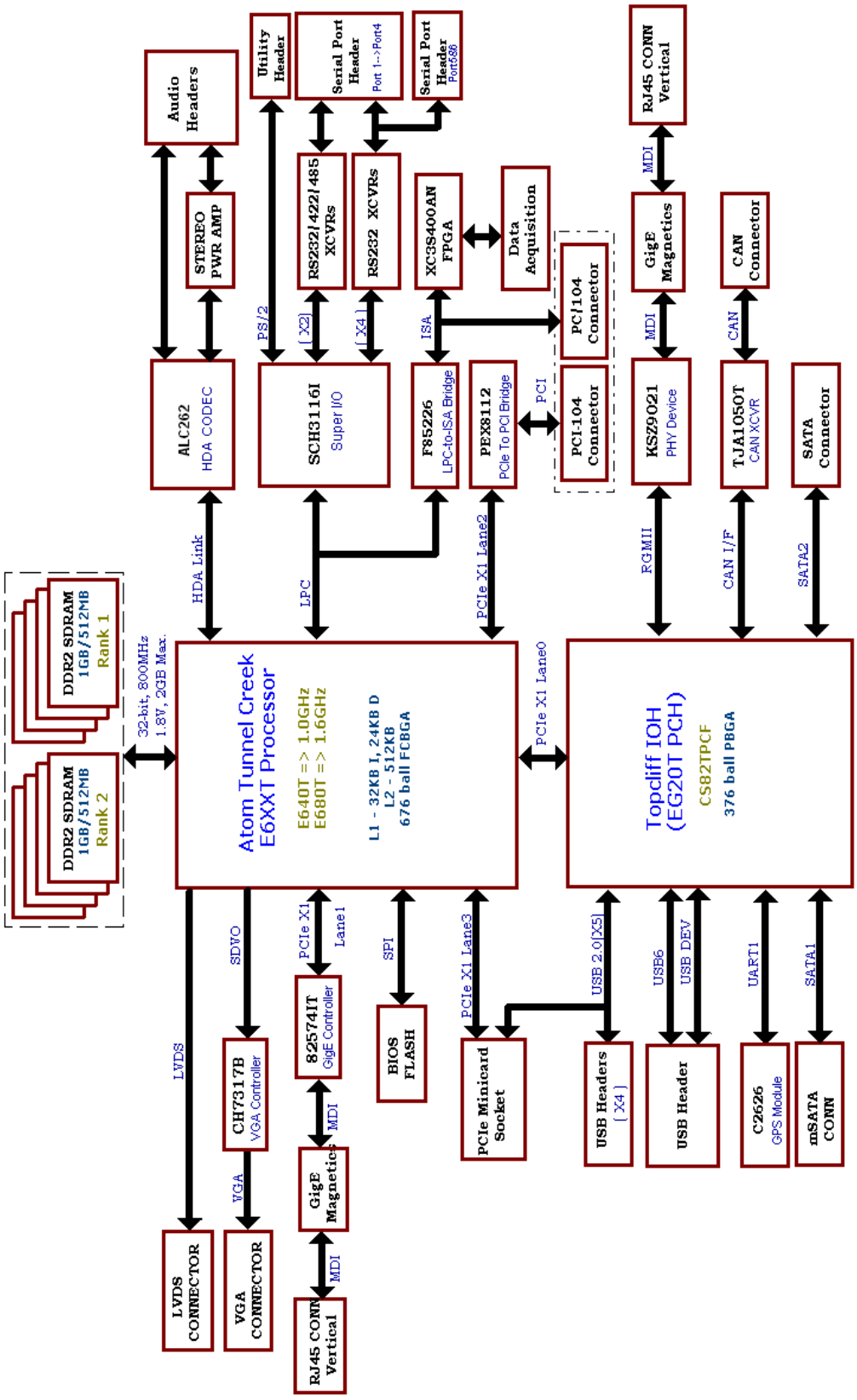
3.3.2 Operating System Drivers

Hercules III will boot and run the operating system from the mSATA flashdisk as defined by which Development Kit was ordered. Hercules III should now be fully operational.

If you desire to run a different operating system, depending on the operating system to be installed, it may be necessary to install software drivers for on-board interface controllers. Drivers for Windows XP, Windows Embedded Standard 7, Windows Embedded CE, and Linux 2.6, if required, are included on the Software and Documentation CD that is included in the Hercules III Development Kit.

4. FUNCTIONAL OVERVIEW

4.1 Functional Block Diagram



4.2 Functional Overview

This section describes the major Hercules III subsystems.

4.2.1 CPU Core

Hercules III's core embedded computer circuit features the ultra low power Intel Atom "Queensbay" extended temperature platform, consisting of an Atom processor ("Tunnel Creek") with I/O Hub ("Topcliff"). The rest of the circuit consists of 1GB or 2GB of on-board SDRAM memory, display controller with LVDS and onboard VGA/ DVI converter, plus SATA, USB, serial port and LAN interfaces. Off-board system buses include PCI Express and ISA.

4.2.2 Video

The video circuit consists of Intel's integrated GMA500 controller with dual independent display support. A 24-bit, single-channel LVDS hardware interface is provided as an interface to LCD displays. The LVDS transmitter operates at 112MHz, with resolutions up to 1366x768 pixels.

CRT resolution of up to 1280x1024 pixels is supported by conversion from the Tunnel Creek through a single SDVO interface to analog VGA with a Chrontel chip.

Simultaneous CRT and LCD support is provided.

In addition, the chipset integrated video controller provides hardware acceleration for H.264, MPEG2, VC1 and WMV9 video decoding standards.

4.2.3 Ethernet

Hercules III provides dual Gigabit Ethernet ports, one supported from the Top Cliff's internal MAC and the other from the Intel 82574IT Gigabit MAC/PHY. Both ports provide a vertical RJ-45 connector with integrated agnetic.

The Wake-On-LAN feature requires integration with the board's power supply and Hercules III BIOS.

4.2.4 USB

Hercules III offers 5 user accessible USB 2.0 ports. All ports have minimum 500mA per port drive capability with short circuit / over current and ESD protection on each port. All of the ports are brought out to I/O connectors for user access.

4.2.5 mSATA Solid State Storage

A mSATA connector provides mounting for a solid state bootable USB flashdisk module with capacity up to 64GB. Both MLC and SLC mSATA devices are supported and available.

4.2.6 Audio

Hercules III provides HD audio support from the Tunnel Creek CPU via a Realtek ALC262 high definition CODEC.

Audio I/O includes stereo line in, stereo line out, amplified out and mono mic in. The board includes audio power amplifier circuitry for stereo speaker output. The amplifier circuit is powered by +5VDC from the board. User DC control of volume is provided which overrides the software settings.

4.2.7 Serial Ports

Hercules III provides six serial ports with varying protocols and signal availability. The SCH3116 provides all of the serial ports. Four of the serial ports (COM1-4) support RS-232/422/485 protocols. The other two ports (COM5-6) support RS-232 only.

The BIOS supports serial console redirection on COM1. This feature enables keyboard input and character video output to be routed to COM1.

4.2.8 GPS Module

Hercules III supports a plug-in Condor C2626 GPS module. The Condor C2626 provides an L1 Frequency (1575.42MHz) GPS receiver with NMEA protocol from a serial port. UART1 from Top Cliff is interfaced with the GPS module.

4.2.9 CAN Interface

Hercules III provides one channel of CAN 2.0 with transceiver.

4.2.10 Data Acquisition

The board provides the following data acquisition capabilities.

Type of I/O	*Characteristics*
Analog Input	32 single-ended/16 differential inputs, 16-bit resolution. 250KHz maximum aggregate A/D sampling rate. Programmable input ranges/gains: +/-10V, +/-5V, +/-2.5V, +/-1.25V, 0-10V, 0-5V, 0-2.5V. A/D 2048 FIFO for reliable high-speed sampling and scan operation.
Analog Output	Four analog outputs, 12-bit resolution. ±10V and 0-10V output ranges. Indefinite short circuit protection on outputs.
PWM	4 pulse width modulator circuits
Digital I/O	40 programmable digital I/O, 3.3V and 5V logic compatible.
Counter/Timers	One 24-bit counter/timer for A/D sampling rate control. One 16-bit counter/timer for user counting and timing functions.

On board I^2C flash EEROM is provided for auto-calibration value storage.

4.2.11 PC/104-*Plus* Expansion Bus

The PC/104-*Plus* expansion bus offers both the ISA bus and PCI bus, and enables installation of additional I/O boards. It consists of two stack-through connectors press-fit onto the board, enabling expansion both above and below the board.

4.2.12 Power Supply

Hercules III contains an on-board DC/DC power supply with 55 watts of output power. With approximately 13.8W required to power the SBC, this leaves 35W available to power peripherals and add-on boards. The +7-40VDC input range means that Hercules III is compatible with vehicle, battery or industrial power sources. The on-board supply features ACPI compatibility for intelligent power management.

4.2.13 Battery Backup

Hercules III includes a backup battery for CMOS RAM and real-time clock backup. The battery is mounted on the top side of the board. The battery provides a minimum of 5 years backup capability at 25°C with the system powered off.

A connector and jumper are provided to disable the on-board battery and enable use of an external battery instead. External battery voltage requirement is 3.3V +/- 10%. The jumper also clears the CMOS RAM when it is removed and no external battery is connected.

4.2.14 Watchdog Timer

A programmable watchdog timer (WDT) is included to provide an automatic reset in case of system hang. The WDT may be retriggered either by a software command or a digital input. The system will reset when the WDT is enabled and expires. The WDT circuitry is integrated in the FPGA chip.

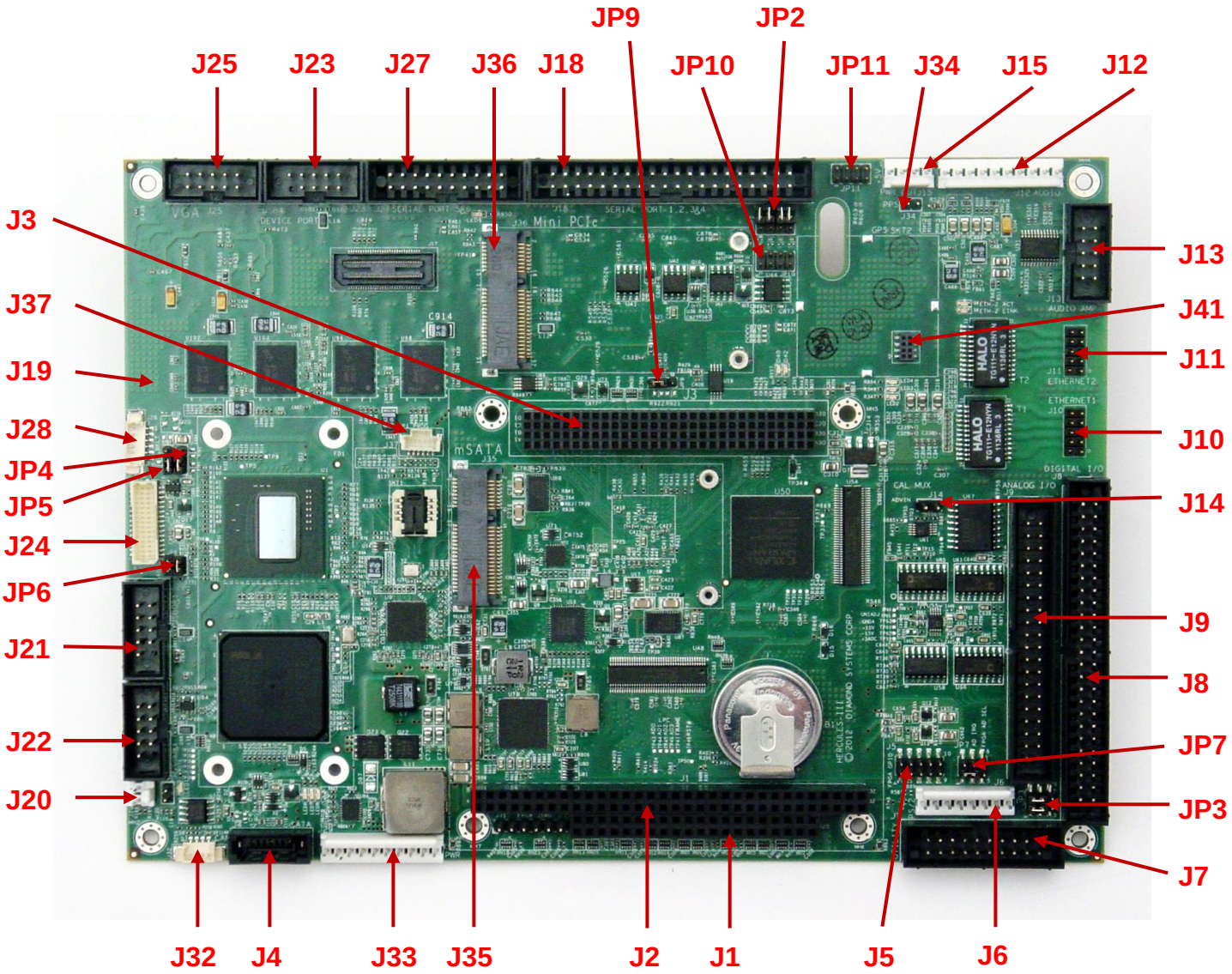
4.2.15 BIOS

The AMI BIOS includes the following key features:

- Boot from LAN (PXE) and USB as well as C: and D:
- User selectable Master boot device selection
- Free boot sequence configuration
- Support for various LCD configurations supported by the video chipset
- Console (display and keyboard) redirection to serial port
- DSC-configurable default settings in battery-less configurations
- Initialize USB keyboard & mouse
- Customizable splash screen

5. BOARD LAYOUT

The figure below shows the Hercules III board layout, including connectors, jumper blocks and mounting holes.



5.1 Connector Summary

The following table lists the connectors on the Hercules III SBC.

Connector	*Description*
J1	PC/104, ISA bus A,B
J2	PC/104, ISA bus C,D
J3	PCI-104, PCI bus
J4	SATA
J6	PS/2 Keyboard & Mouse
J7	Utility
J8	Digital I/O
J9	Analog I/O
J10, J11	Gigabit Ethernet
J12	Audio I/O
J13	Audio Amp
J14	ADC Calibration
J15	External Auxiliary Power
J18	Serial Ports 1, 2, 3, & 4
J20	External Battery
J21	USB 0/1
J22	USB 2/3
J23	USB 4 , USB Device
J24	LVDS LCD
J25	VGA
J27	Serial Ports 5 & 6
J28	LCD backlight power
J32	CANbus
J33	Power Input
J34	GPS PPS
J35	mSATA Socket
J36	PCIe MiniCard Socket
J41	GPS Socket

5.2 Jumper Summary

The following table lists the jumper blocks on the Hercules III SBC.

Jumper	*Description*
JP2	COM3 & COM4 RS-485/422 termination
JP3	Digital I/O configuration
JP4	LCD VDD select
JP5	LCD backlight VDD select
JP6	LCD scan direction and frame rate setting
JP7	IRQ & FPGA address selection
JP9	PC/104-*Plus* VIO selection
JP10	COM3 configuration
JP11	COM4 configuration

6. CONNECTORS

This section describes the on-board Hercules III connectors.

> **Note:** All cables mentioned in this chapter are included in Diamond Systems' cable kit C-HRCE-KIT. Some cables are also available individually.

6.1 PC/104 ISA Bus (J1, J2)

Connectors J1 and J2 carry the ISA bus signals. The following diagram shows the PC/104 A and B pin layout for J1 and the C and D pin layout for J2.

J1

IOCHCHK-	A1	B1	Ground
SD7	A2	B2	RESETDRV
SD6	A3	B3	+5V
SD5	A4	B4	IRQ9
SD4	A5	B5	-5V
SD3	A6	B6	DRQ2
SD2	A7	B7	-12V
SD1	A8	B8	ENDXFR-
SD0	A9	B9	+12V
IOCHRDY	A10	B10	Key
AEN	A11	B11	SMEMW-
SA19	A12	B12	SMEMR-
SA18	A13	B13	IOW-
SA17	A14	B14	IOR-
SA16	A15	B15	DACK3-
SA15	A16	B16	DRQ3
SA14	A17	B17	DACK1-
SA13	A18	B18	DRQ1
SA12	A19	B19	REFRESH-
SA11	A20	B20	SYSCLK
SA10	A21	B21	IRQ7
SA9	A22	B22	IRQ6
SA8	A23	B23	IRQ5
SA7	A24	B24	IRQ4
SA6	A25	B25	IRQ3
SA5	A26	B26	DACK2-
SA4	A27	B27	TC
SA3	A28	B28	BALE
SA2	A29	B29	+5V
SA1	A30	B30	OSC
SA0	A31	B31	Ground
Ground	A32	B32	Ground

J2

Ground	C0	D0	Ground
SBHE-	C1	D1	MEMCS16--
LA23	C2	D2	IOCS16-
LA22	C3	D3	IRQ10
LA21	C4	D4	IRQ11
LA20	C5	D5	IRQ12
LA19	C6	D6	IRQ15
LA18	C7	D7	IRQ14
LA17	C8	D8	DACK0-
MEMR-	C9	D9	DRQ0
MEMW-	C10	D10	DACK5-
SD8	C11	D11	DRQ5
SD9	C12	D12	DACK6-
SD10	C13	D13	DRQ6
SD11	C14	D14	DACK7-
SD12	C15	D15	DRQ7
SD13	C16	D16	+5
SD14	C17	D17	MASTER-
SD15	C18	D18	Ground
Key	C19	D19	Ground

6.2 PCI-104 Bus (J3)

The PCI-104 bus connector is a non-stackthrough connector with short PCB pins. The bus stacks upward only. No pin shroud is required on the bottom side.

J3				
Pin	**A**	**B**	**C**	**D**
1	GND/5.0V KEY[2]	Reserved	+5	AD00
2	VI/O	AD02	AD01	+5V
3	AD05	GND	AD04	AD03
4	C/BE0*	AD07	GND	AD06
5	GND	AD09	AD08	GND
6	AD11	VI/O	AD10	M66EN
7	AD14	AD13	GND	AD12
8	+3.3V	C/BE1*	AD15	+3.3V
9	SERR*	GND	SB0*	PAR
10	GND	PERR*	+3.3V	SDONE
11	STOP*	+3.3V	LOCK*	GND
12	+3.3V	TRDY*	GND	DEVSEL*
13	FRAME*	GND	IRDY*	+3.3V
14	GND	AD16	+3.3V	C/BE2*
15	AD18	+3.3V	AD17	GND
16	AD21	AD20	GND	AD19
17	+3.3V	AD23	AD22	+3.3V
18	IDSEL0	GND	IDSEL1	IDSEL2
19	AD24	C/BE3*	VI/O	IDSEL3
20	GND	AD26	AD25	GND
21	AD29	+5V	AD28	AD27
22	+5V	AD30	GND	AD31
23	REQ0*	GND	REQ1*	VI/O
24	GND	REQ2*	+5V	GNT0*
25	GNT1*	VI/O	GNT2*	GND
26	+5V	CLK0	GND	CLK1
27	CLK2	+5V	CLK3	GND
28	GND	INTD*	+5V	RST*
29	+12V	INTA*	INTB*	INTC*
30	-12V	Reserved	Reserved	GND/3.3V KEY[2]

6.3 SATA (J4)

Industry standard vertical SATA connector.

6.4 Utility (J7)

A 20-pin connector provides access to the standard button/LED connections. Cable C-20-18 is used to connect to J7.

Ground	1	2	Reset Key
Ground	3	4	Power Button
Network : Activity LED	5	6	+3.3V Standby
Network : Link LED	7	8	+3.3V Standby
+5V In	9	10	SATA LED
Power LED	11	12	External Battery
Watch Dog Timer - Input	13	14	Ground
SPEAKER	15	16	Watch Dog Timer - Output
+5V In	17	18	N/C
N/C	19	20	Ground

Connector type: Shrouded .1" dual row straight pin header with gold flash plating

6.5 Digital I/O (J8)

Hercules III includes a 50-pin header, J8, for all digital I/O.

J8 Digital I/O Connector

DIO A0	1	2	DIO A1
DIO A2	3	4	DIO A3
DIO A4	5	6	DIO A5
DIO A6	7	8	DIO A7
DIO B0	9	10	DIO B1
DIO B2	11	12	DIO B3
DIO B4	13	14	DIO B5
DIO B6	15	16	DIO B7
DIO C0	17	18	DIO C1
DIO C2	19	20	DIO C3
DIO C4	21	22	DIO C5
DIO C6	23	24	DIO C7
DIO D0	25	26	DIO D1
DIO D2	27	28	DIO D3
DIO D4	29	30	DIO D5
DIO D6	31	32	DIO D7
DIO E0 / PWM0	33	34	DIO E1 / PWM1
DIO E2 / PWM2	35	36	DIO E3 / PWM3
DIO E4 / GATE1	37	38	DIO E5 / TOUT1

DIO E6 / DIOLATCH	39	40	DIO E7 / GATE0
EXTTRIG	41	42	TOUT0
ACK	43	44	WDI
WDO	45	46	FXA
FXB	47	48	FXB
+5V	49	50	Digital Ground

Signal	***Definition***
DIO A7-A0	Digital I/O port A; programmable direction
DIO B7-B0	Digital I/O port B; programmable direction
DIO C7-C0	Digital I/O port C; programmable direction
DIO D7-D0	Digital I/O port D; programmable direction
DIO E7-E0	Digital I/O port E; programmable direction E3-E0 may be configured for PWM signals
EXTTRIG	External A/D trigger input
TOUT0/1	Counter/Timer 0/1 output
PWM0-3	Pulse width modulator signals
WDI/O	Watchdog timer input/output
+5V out	Connected to switched +5V supply (Output only! Do not connect to external supply)
DGND	Digital ground (0V - reference); used for digital circuitry only

Diamond Systems cable number C-50-18 provides a standard 50-pin connector at each end and mates with this header.

Connector type: Hirose DF50 1mm, RA, pos. lock, 50 pins

6.6 Analog I/O (J9)

Hercules III models with analog data acquisition include a 40-pin header, J9, for the analog I/O features. The pinout definition depends on the analog input jumper configuration. This is available only on models with data acquisition.

Single-Ended			
Vout 0	1	2	Vout 1
Vout 2	3	4	Vout 3
Output Ground	5	6	Output Ground
Vin 0	7	8	Vin 16
Vin 1	9	10	Vin 17
Vin 2	11	12	Vin 18
Vin 3	13	14	Vin 19
Vin 4	15	16	Vin 20
Vin 5	17	18	Vin 21
Vin 6	19	20	Vin 22
Vin 7	21	22	Vin 23
Vin 8	23	24	Vin 24
Vin 9	25	26	Vin 25
Vin 10	27	28	Vin 26
Vin 11	29	30	Vin 27
Vin 12	31	32	Vin 28
Vin 13	33	34	Vin 29
Vin 14	35	36	Vin 30
Vin 15	37	38	Vin 31
Input Ground	39	40	Input Ground

Differential			
Vout 0	1	2	Vout 1
Vout 2	3	4	Vout 3
Output Ground	5	6	Output Ground
Vin 0 +	7	8	Vin 0 -
Vin 1 +	9	10	Vin 1 -
Vin 2 +	11	12	Vin 2 -
Vin 3 +	13	14	Vin 3 -
Vin 4 +	15	16	Vin 4 -
Vin 5 +	17	18	Vin 5 -
Vin 6 +	19	20	Vin 6 -
Vin 7 +	21	22	Vin 7 -
Vin 8 +	23	24	Vin 8 -
Vin 9 +	25	26	Vin 9 -
Vin 10 +	27	28	Vin 10 -
Vin 11 +	29	30	Vin 11 -
Vin 12 +	31	32	Vin 12 -
Vin 13 +	33	34	Vin 13 -
Vin 14 +	35	36	Vin 14 -
Vin 15 +	37	38	Vin 15 -
Input Ground	39	40	Input Ground

Connector type: Hirose DF50 1mm, RA, pos. lock, 40 pins

Diamond Systems cable number C-40-18 provides a standard 40-pin connector at each end and mates with this header.

6.7 Gigabit Ethernet (J10, J11)

Hercules III provides 2 Gigabit Ethernet ports, each with the following pinout.

NC	1	2	Key / Cut
DA+	3	4	DA-
DB+	5	6	DB-
DC+	7	8	DC-
DD+	9	10	DD-

Connector type: Standard 2mm pitch vertical header with external magnetics

Diamond Systems cable number 6981080 mates with these headers.

6.8 Audio (J12)

1	LEFT Headphone / Line Out
2	RIGHT Headphone / Line Out
3	Audio Ground
4	LEFT Line Input
5	RIGHT Line Input
6	LEFT AUX Input
7	RIGHT AUX Input
8	Audio Ground
9	Power Reference for Microphone
10	Microphone Input

Connector type: Vertical .1" pitch friction lock connector; Tyco 1-640456-0 or equivalent

Diamond Systems cable number 6981025 mates with this header.

6.9 Audio AMP (J13)

Speaker Left +	1	2	Volume Low
Speaker Left -	3	4	Volume Mid (Wipe)
Line level Mono output	5	6	Audio Ground
Speaker Right -	7	8	Volume High
Speaker Right +	9	10	NC

Connector type: Shrouded .1" dual row straight pin header with gold flash plating

6.10 External Auxiliary Power (J15)

1	+5V switched
2	Ground
3	Ground
4	+12V switched

Connector type: Vertical .1" pitch friction lock connector

Connector on board: Tyco 640456-4 pin header or equivalent

6.11 Serial Ports 1, 2, 3, 4 (J18)

J18 is a 40-pin header that provides access to serial ports 1, 2, 3 and 4. The pinout depends on the protocol selection. The pinouts below show all ports with the same protocol; however each port may have its own protocol selection.

	RS-232 Configuration				RS-485 Configuration				RS-422 Configuration			
Port 1	DCD 1	1	2	DSR 1	NC	1	2	NC	NC	1	2	NC
	RXD 1	3	4	RTS 1	TXD/RXD+ 1	3	4	TXD/RXD- 1	TXD+ 1	3	4	TXD- 1
	TXD 1	5	6	CTS 1	GND	5	6	NC	GND	5	6	RXD- 1
	DTR 1	7	8	RI 1	NC	7	8	NC	RXD+ 1	7	8	NC
	GND	9	10	NC	GND	9	10	NC	GND	9	10	NC
Port 2	DCD 2	11	12	DSR 2	NC	11	12	NC	NC	11	12	NC
	RXD 2	13	14	RTS 2	TXD/RXD+ 2	13	14	TXD/RXD- 2	TXD+ 2	13	14	TXD- 2
	TXD 2	15	16	CTS 2	GND	15	16	NC	GND	15	16	RXD- 2
	DTR 2	17	18	RI 2	NC	17	18	NC	RXD+ 2	17	18	NC
	GND	19	20	NC	GND	19	20	NC	GND	19	20	NC
Port 3	DCD 3	21	22	DSR 3	NC	21	22	NC	NC	21	22	NC
	RXD 3	23	24	RTS 3	TXD/RXD+ 3	23	24	TXD/RXD- 3	TXD+ 3	23	24	TXD- 3
	TXD 3	25	26	CTS 3	GND	25	26	NC	GND	25	26	RXD- 3
	DTR 3	27	28	RI 3	NC	27	28	NC	RXD+ 3	27	28	NC
	GND	29	30	NC	GND	29	30	NC	GND	29	30	NC
Port 4	DCD 4	31	32	DSR 4	NC	31	32	NC	NC	31	32	NC
	RXD 4	33	34	RTS 4	TXD/RXD+ 4	33	34	TXD/RXD- 4	TXD+ 4	33	34	TXD- 4
	TXD 4	35	36	CTS 4	GND	35	36	NC	GND	35	36	RXD- 4
	DTR 4	37	38	RI 4	NC	37	38	NC	RXD+ 4	37	38	NC
	GND	39	40	NC	GND	39	40	NC	GND	39	40	NC

Connector type: Standard 2.54mm dual row straight pin header with 4mm posts and gold flash plating

Diamond Systems cable number C-DB9M-4 provides a standard DB9 connector at each end and mates with this header.

6.12 External Battery (J20)

Connector J20 is used to connect an external battery for maintaining the real-time clock and CMOS settings (BIOS settings for various system configurations). The battery voltage for this input should be 3-3.6VDC. The current draw averages under 4µA at 3V. Use cable 6981011 with J20.

J20 External Battery Connector (end view)

1	Battery input (+)
2	Ground

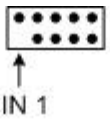
Connector type: Vertical .1” pitch friction lock connector

Connector on board: Tyco 640456-2 pin header or equivalent

6.13 USB (J21, J22)

Connectors J21 (USB 0/1) and J22 (USB 2/3) provide four USB 2.0 ports. The connectors have identical pinouts as described below.

J21/J22 USB Connectors



Key (pin cut)	1	2	Shield
USB 1/3 Power -	3	4	USB 0/2 Power -
USB1/3 D+	5	6	USB0/2 D+
USB1/3 D-	7	8	USB0/2 D-
USB1/3 VCC	9	10	USB0/2 VCC

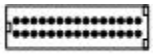
Connectors J21 and J22 mate with Diamond Systems cable number 6981012, which provides two standard USB type A jacks in a panel-mount housing.

Connector type: Standard 2.54mm dual row straight pin header with 4mm posts and gold flash plating

6.14 LCD Panel, LVDS Interface (J24)

Connector J24 provides access to the internal LVDS LCD display drivers. Note that the LCD also requires the backlight to be connected (see J28 below) to function correctly. The LCD panel power is jumper-selectable for 3.3V (default) or 5V. The Intel Atom E-Series CPU has maximum allowable LCD support of 1280 x 768.

J24 LCD Panel Connector



Ground	1	2	Ground
LVDS clock-	3	4	
LVDS clock+	5	6	
Ground	7	8	Ground
LVDS data 0-	9	10	LVDS data 3+
LVDS data 0+	11	12	LVDS data 3-
Ground	13	14	Ground
LVDS data 2-	15	16	
LVDS data 2+	17	18	
Ground	19	20	Ground

LVDS data 1+	21	22	Scan Direction
LVDS data 1-	23	24	LVDS Map
Ground	25	26	Ground
VDD (LCD display)	27	28	VDD (LCD display)
VDD (LCD display)	29	30	VDD (LCD display)

Signal	***Definition***
LVDS Data 0-2 +/-	Primary Data Channel, bits 0-2 (LVDS Differential signaling)
LVDS Clock +/-	Primary Data Channel, Clock (LVDS Differential signaling)
LVDS Data 0-2 +/-	Secondary Data Channel, bits 0-2 (LVDS Differential signaling)
LVDS Clock +/-	Secondary Data Channel, Clock (LVDS Differential signaling)
VDD	+3.3V Switched Power Supply for LCD display (only powered up when LCD display is active)
Ground	Power Ground, 0V

Connector on board: JST model number BM30B-SRDS-G-TF or equivalent

Mating cable connector: JST model number SHDR-30V-S-B or equivalent
Terminals: JST model number SSH-003GA-P0.2 or equivalent

6.15 VGA (J25)

Connector J25 is a 2x5-pin header for connecting a VGA monitor.

J25 VGA Connector

Red	1	2	R-Ground
Green	3	4	G-Ground
Blue	5	6	B-Ground
HSynch	7	8	DDC-Data
VSynch	9	10	DDC-Clock

Signal	***Definition***
Ground	Ground return
Red	RED signal (positive, 0.7Vpp into 75 Ohm load)
Green	GREEN signal (positive, 0.7Vpp into 75 Ohm load)
Blue	BLUE signal (positive, 0.7Vpp into 75 Ohm load)
DDC clock/data	Digital serial I/O signals used for monitor detection (DDC1 specification)
HSYNC	Horizontal sync
VSYNC	Vertical sync

Note: While the DDC serial detection pins are present, a 5V power supply is not provided (the old "Monitor ID" pins are also not used).

Diamond Systems cable number 6981024 provides a female DB15 connection to interface with a standard RGB monitor.

Connector type: Standard 2.54mm dual row straight pin header with 4mm posts and gold flash plating

6.16 Serial Ports 5, 6 (J27)

	NC	1	2	NC
	RXD 5	3	4	RTS 5
Port 5	TXD 5	5	6	CTS 5
	NC	7	8	NC
	GND	9	10	NC
	NC	11	12	NC
	RXD 6	13	14	RTS 6
Port 6	TXD 6	15	16	CTS 6
	NC	17	18	NC
	GND	19	20	NC

Diamond Systems cable number C-DB9M-2 provides a standard DB9 connector at each end and mates with this header.

6.17 LCD Backlight (J28)

Connector J28 provides the backlight power and control for the optional LCD panel. See the description for connector J24, above, for details on the LCD data interface.

J28 LCD Backlight Connector (end view)

1	VDD
2	VDD
3	Ground
4	Ground
5	BKLTEN
6	BKLTCTL

The brightness control for the LCD backlight has a weak pull-down resistor to ensure maximum brightness when it is not connected externally.

Connector on board: Vertical 1.25mm pitch connector; Molex 53398-0671 or equivalent

6.18 CAN (J32)

NC	1	2	CAN Ground
CAN Data -	3	4	CAN Data +
Ground	5	6	NC
NC	7	8	Vcc
NC	9	10	NC

Connector type: 1.25mm single row straight connector from Molex or equivalent

Diamond Systems cable number 6981314 mates with this header.

6.19 Power Input (J33)

Input power for Hercules III may be supplied either from an external supply, through J21, or directly through the PC/104-*Plus* bus power pins if a PC/104 power supply is used with the SBC.

1	+VIn
2	+Vin
3	Ground
4	Ground
5	+12V
6	Ground
7	+Vin
8	-12V
9	-5V
10	Power Supply On

- Hercules III requires only +5VDC input power to operate. All other required voltages are generated on board with miniature switching regulators. However since the PC/104-*Plus* bus includes pins for ±5V and ±12V, these voltages may be supplied through J11 if needed. The +5V and +12V voltages are controlled by the ATX power manager switches, while -5V and -12V are routed directly to the corresponding pins on PC/104 bus and are not controlled by the ATX function. External +12V is required for the LCD backlight.
- Make sure that the power supply used has enough current capacity to drive your system. The Hercules III SBC requires up to 3A on the +5V line. If you have a disk drive or other modules connected, you need additional power. In particular, many disk drives need extra current during startup. If your system fails to boot properly, or if disk accesses do not work properly, the first thing to check is the power supply voltage level. Many boot-up problems are caused simply by insufficient voltage due to excess current draw on the +5V supply.
- Multiple +5V and Ground pins are provided for extra current carrying capacity if needed. Each pin is rated at 3A max (15W). For the Hercules III SBC and panel I/O board 3A is sufficient, so +5V and Ground require only a single wire each. In this case the first 4 pins may be connected to a standard 4-pin miniature PC power connector if desired. Be advised that some voltage will be dropped in the wire depending on the wire gauge (AWG).
- For a larger PC/104 stack the total power requirements should be calculated to determine whether additional wires are necessary.

- ATX control enables the +5V and +12V power to be switched on and off with an external momentary switch. A short press on the switch will turn on power, and holding the switch on for 4 seconds or longer will turn off power

Diamond Systems cable number 6981015 mates with this header.

6.20 mSATA (J35)

The mSATA connector is for cable-free connection to a SATA SSD module. The 52-pin mSATA connector supports mSATA modules.

Signal Name	Pin#	Pin #	Signal Name
NC	1	2	+3.3V
NC	3	4	GND
NC	5	6	NC
NC	7	8	NC
GND	9	10	NC
NC	11	12	NC
NC	13	14	NC
GND	15	16	NC
Key			
NC	17	18	GND
NC	19	20	NC
GND	21	22	NC
TX+	23	24	+3.3V
TX-	25	26	GND
GND	27	28	NC
GND	29	30	NC
RX-	31	32	NC
RX+	33	34	GND
GND	35	36	NC
GND	37	38	NC
+3.3V	39	40	GND
+3.3V	41	42	NC
GND	43	44	NC
NC	45	46	NC
NC	47	48	NC
DA/DSS	49	50	GND
PRSNT#	51	52	+3.3V

6.21 PCIe MiniCard (J36)

The 52 pin min PCI Express connector supports add-on PCIe MiniCards.

Pin#	Name	Pin#	Name
1	WAKE#	2	3.3Vaux
3	COEX1	4	GND
5	COEX2	6	1.5V
7	CLKREQ#	8	UIM_PWR
9	GND	10	UIM_DATA
11	REFCLK-	12	UIM_CLK
13	REFCLK+	14	UIM_RESET
15	GND	16	UIM_VPP
Mechanical Key			
17	Reserved* (UIM_C8)	18	GND
19	Reserved* (UIM_C4)	20	W_DISABLE#
21	GND	22	PERST#
23	PERn0	24	+3.3Vaux
25	PERp0	26	GND
27	GND	28	+1.5V
29	GND	30	SMB_CLK
31	PETn0	32	SMB_DATA
33	PETp0	34	GND
35	GND	36	USB_D-
37	GND	38	USB_D+
39	+3.3Vaux	40	GND
41	+3.3Vaux	42	LED_WWAN#
43	GND	44	LED_WLAN#
45	Reserved	46	LED_WPAN#
47	Reserved	48	+1.5V
49	Reserved	50	GND
51	Reserved	52	+3.3Vaux

7. JUMPER CONFIGURATION

The Hercules III board has the following jumper-selectable configuration options.

Jumper Block	*Configuration Functions*
JP2	COM3 & COM4 RS-422/485 termination
JP3	Digital I/O configuration
JP4	LCD VDD select
JP5	LCD backlight VDD select
JP6	LCD scan direction and frame rate setting
JP7	IRQ & FPGA address Selection
JP9	PC/104-*Plus* VIO selection
JP10	COM3 RS-485/422 pull-up
JP11	COM4 RS-485-422 pull-up

7.1 COM3 & COM4 RS-422/285 Termination (JP2)

JP2 provides 120ohm termination on the D+/D- and RxD_/RxD- lines for COM3 and COM4 RS-422/485 configurations per the following table. The default is no jumpers installed

Pins	Jumper installed	Default
1-2	Provides 120Ω termination between the D+/D- lines in RS-485 mode for COM3	No jumper
3-4	Provides 120Ω termination between the RxD+/RxD- lines in RS-422 mode for COM3	No jumper
5-6	Provides 120Ω termination between the D+/D- lines in RS-485 mode for COM4	No jumper
7-8	Provides 120Ω termination between the RxD+/RxD- lines in RS-422 mode for COM4	No jumper

7.2 Digital I/O Configuration (JP3)

The 40 digital I/O lines have 47Kohm pull resistors that may be configured for pull-up or pull-down with a jumper per the following table. The default is 47Kohm pull-up.

Pins	Jumper installed	Default
1-3	Provides 47K pull up on DIO lines	Jumper
2-4	Provides 47K pull up on DIO lines	Jumper
3-5	Provides 47K pull down on DIO lines	No jumper
4-6	Provides 47K pull down on DIO lines	No jumper

7.3 LCD Panel Configuration (JP4, JP5, JP6)

Hercules III has three jumpers that set the LCD configuration.

JP4: LCD panel supply voltage +3.3V or +5V

Pins	Jumper installed	Default
1-2	+5V LCD VDD	No jumper
2-3	+3.3V LCD VDD	Jumper

JP5: LCD backlight power +5V or +12V (+12V provided through the input power connector)

Pins	Jumper installed	Default
1-2	+5V LCD backlight power	Jumper
2-3	+12V LCD backlight power	No jumper

JP6: LCD panel scan direction and frame rate control

Pins	Jumper installed	Jumper not installed	Default
1-2	Scan direction: Normal scan	Scan direction: Reverse scan	Jumper
3-4	Frame Rate Control: Off	Frame Rate Control: On	Jumper

7.4 IRQ & FPGA Address Selection (JP7)

JP7 sets the A/D IRQ and the address of the FPGA as follows.

Pins	Jumper installed	Jumper not installed	Default
1-3	A/D IRQ 5		Jumper
3-4	A/D IRQ 7		No jumper
5-6	FPGA address: x260	FPGA address: x240	No jumper

7.5 PCI-104 Connector VIO (JP9)

Jumper JP9 enables selection of +3.3V or +5V for VIO on the PCI-104 connector as follows.

Pins	Jumper installed	Default
1-2	+5V PCI VIO power	No jumper
2-3	+3.3V PCI VIO power	Jumper

7.6 COM3 & COM4 Configuration (JP10, JP11)

COM3 and COM4 can be configuration as follows using jumpers JP10 and JP11 respectively. The jumper settings work the same on both J10 and J11.

Pins	Jumper installed	Default
1-3	Provides 47K pull up on RXD	No jumper
3-4	Provides 47K pull down on RTS	No jumper
5-6	Provides 47K pull up on DTR	No jumper
7-8	Provides 47K pull down on CTS	No jumper

8. SYSTEM OPERATION

8.1 System Resources

The table below lists the system resources utilized by the circuits on Hercules III.

Device	*Default Address*	*ISA IRQ*	*ISA DMA*	*Selectable Addresses*
Serial Port COM1	I/O 0x3F8	4	–	2F8, 3E8, 2E8
Serial Port COM2	I/O 0x2F8	3	–	3F8, 3E8, 2E8
Serial Port COM3	I/O 0x3E8	4	–	–
Serial Port COM4	I/O 0x2E8	3	–	–
Serial Port COM5	I/O 0x100	4	–	–
Serial Port COM6	I/O 0x108	3	–	–
FPGA	I/O 0x240	5	3	278, 3BC
A/D Circuit (when applicable)	I/O 0x280 – 0x28F	4,5,6	–	–
Watchdog Timer/Serial Port/FPGA	I/O 0x25C-0x25F	–	–	–
Ethernet	OS-dependent	OS-dependent	–	–
USB	OS-dependent	OS-dependent	–	–
Sound	OS-dependent	OS-dependent	–	–
Video	OS-dependent	OS-dependent	–	–

Note: In the preceding table, the selectable addresses are declared in CMOS BIOS.

Most of these resources are configurable and, in many cases, the operating system alters these settings. The main devices that are subject to this dynamic configuration are on-board Ethernet, sound, video, USB, and any PC/104-*Plus* cards that are in the system. These settings may also vary depending on what other devices are present in the system. For example, adding a PC/104-*Plus* card may change the on-board Ethernet resources.

8.2 Console Redirection to a Serial Port

In many applications without a local display and keyboard, it may be necessary to obtain keyboard and monitor access to the CPU for configuration, file transfer, or other operations. Hercules III supports this operation by enabling keyboard input and character output onto a serial port, referred to as console redirection. A serial port on another PC can be connected to the serial port on Hercules III with a null modem cable, and a terminal emulation program, such as HyperTerminal, can be used to establish the connection. The terminal program must be capable of transmitting special characters including F2 (some programs or configurations trap special characters).

The default Hercules III BIOS setting disables console redirection.

There are three possible configurations for console redirection:

- POST-only (default)
- Always On
- Disabled

To modify the console redirection settings:

1. Enter the BIOS.
2. Select the Advanced menu.
3. Select Console Redirection.
4. In Com Port Address, select Disabled to disable the function, On-board COM A for COM1, or On-board COM B for COM2 (default).

If you select Disabled, you will not be able to enter BIOS again during power-up through the serial port.

To reenter BIOS when console redirection is disabled, you must install a video monitor or LCD and use a keyboard. Erasing the CMOS RAM returns the BIOS to its default settings. CMOS RAM may be erased by removing the jumper on the JP10 jumper block.

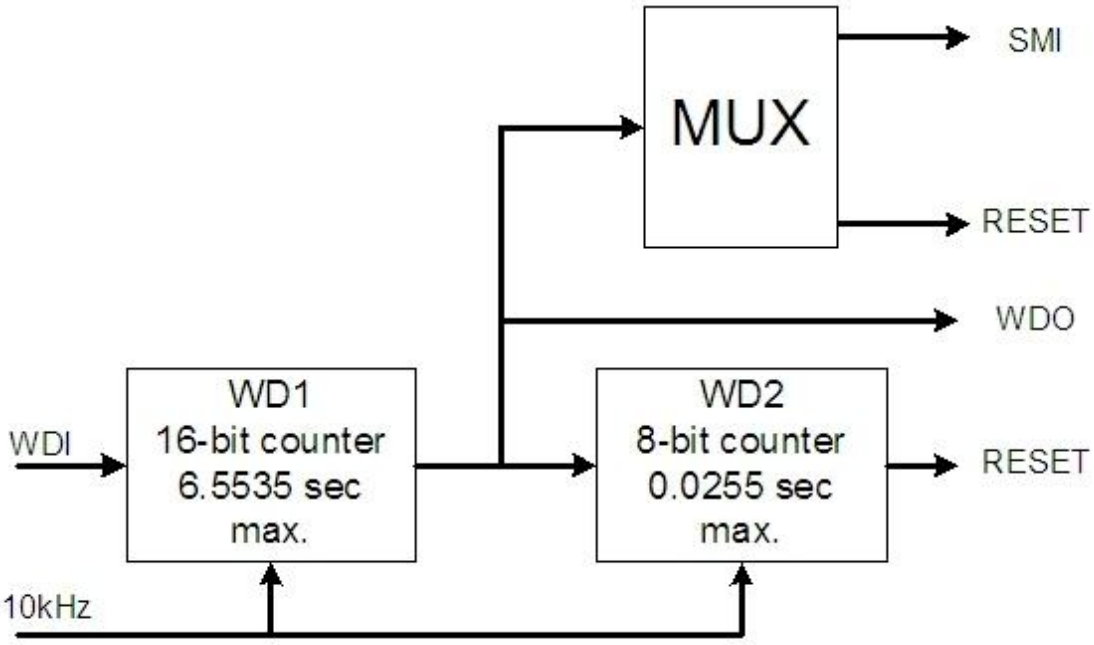
Note: Before erasing CMOS RAM, write down any custom BIOS settings you have made.

If you selected COMA or COMB, continue with the configuration, as follows.

1. For Console Type, select PC ANSI.
2. You can modify the baud rate and flow control here if desired.
3. At the bottom, for Continue C.R. after POST, select Off (default) to turn off after POST or select On to remain on always.
4. Exit the BIOS and save your settings.

8.3 Watchdog Timer

Hercules III contains a watchdog timer circuit provided by the Super I/O controller SCH3116. The watchdog timer can be configured using the BIOS and also using direct register command access mechanism to the SCH3116 controller.



Watchdog Timer Block Diagram

8.4 Backup Battery

Hercules III contains an integrated RTC/CMOS RAM backup battery. This battery has a capacity of 120mAH and will last over five years in power-off state.

The on-board battery is activated for the first time during initial factory configuration and test. Storage temperature of the board can affect the total battery life. Storage at 23ºC is recommended.

8.5 System Reset

Hercules III contains a chip to control system reset operation. Reset occurs under the following conditions.

- User causes reset with a ground contact on the *Reset* input
- Input voltage drops below 4.75V
- Over-current condition on output power line

The ISA Reset signal is an active high pulse with a 200ms duration. The PCI Reset is active low, with a typical pulse width duration of 200 msec.

9. BIOS

Hercules III uses a BIOS from American Megatrends modified to support the custom features of the SBC.

9.1 BIOS Settings

To change the following BIOS settings, press Del during system startup power on self-test (POST).

9.1.1 Serial Ports

The address and interrupt settings for serial ports COM1 and COM2 may be modified. COM1 and COM2 address and interrupt settings are configured using the Advanced, Advanced Chipset Control, I/O Chip Device Configuration menu.

The addresses of COM3 and COM4 are fixed. The IRQ selections for COM3 and COM4 are configured using jumper block JP6.

9.1.2 LCD Video Settings

Hercules provides direct digital support for LVDS-based LCD interfaces only. As such, there are two settings that affect this support during BIOS boot.

Boot Video Device – By default, this is set to “AUTO”. With the AUTO setting, the system attempts to identify an RGB monitor (via DDC). If no RGB monitor is detected, the system enables LCD support. If you choose to use the LCD display regardless of standard monitor connection (i.e., with both connected at once), set “Boot Video Device” to “Both”.

Panel Type – This setting defaults to “7”. Do not alter this setting unless specifically instructed to do so. This setting affects the LCD display modes supported; mode “7” is the only setting currently supported. Not all LCD displays are supported.

9.1.3 Miscellaneous Settings

- Memory Cache

  Unless there is a specific reason to change these settings, it is best to keep these settings as-is. Certain system functions, such as USB keyboard support under BIOS menus, may be adversely affected by changes to these settings. These cache settings can make a noticeable difference for low-level BIOS calls and, as such, can severely limit performance if they are disabled.

- Advanced Chipset Control

  The following settings should be retained:

  Frame Buffer Size: 8MB

  AGP Rate: 4X

  Expansion Bus Performance: Normal

The Frame Buffer size can be increased for specific applications. Be aware, however, that an increase in this memory size will result in a decrease in overall system memory available. The AGP rate affects internal video accesses and does not affect any external bus speeds.

"Expansion Bus Performance" is an adjustment to allow an increase in ISA I/O Access speeds. For applications where ISA I/O accesses seem to be a limiting factor, this performance may be increased to "Accelerated". Be aware that increasing these timings may adversely affect system stability with external add-on PC/104 cards. This setting has no direct affect on PCI or memory speeds; it only affects ISA PC/104 devices. It is best to leave this setting at "Normal," if there are no ISA I/O performance issues.

- Advanced

  Installed O/S: (See Section 23) Select the operating system.

  Large Disk Access Mode: (See Section 23) Select the disk access mode.

- On-Chip Multifunction Device

  USB Device: Enabled/disable USB ports.

  Legacy Audio:

  "Legacy Audio" only affects DOS-based applications when used with the VIA-supported DOS Drivers. Enabling this setting will require system I/O, IRQ, and DMA resources. It is strongly recommended that this setting be left "Disabled."

- PCI and ISA Configuration (from the Advanced menu)

  The following settings should be retained:

  PCI IRQ Level 1-4: Auto-select for all

  PCI/PNP ISA UMB Region Exclusion: Available for all

- Power Management

  This setting is only effective under DOS. Otherwise, the OS power management settings pre-empt these settings. The only power management mode supported by the system is "Power-On Suspend." Other suspend modes are not supported and should not be used under any OS. Examples of unsupported suspend modes include, "Hibernate," under Windows, and "Suspend-to-Disk" or "Suspend-to-RAM".

- Memory Shadow

These parameters should only be modified by advanced users. These settings can adversely affect system performance and reliability.

9.2 BIOS Console Redirection Settings

For applications where the Video interfaces are not used, the textual feedback typically sent to the monitor can be redirected to a COM port. In this manner, a system can be managed and booted without using a video connection.

The BIOS allows the following configuration options for Console Redirection to a COM port.

- COM port address: Disabled (default), COM port A, or COM port B.

  If Console Redirection is enabled here, the associated COM port (with "A" here referring to COM 1 and "B" referring to COM 2) is enabled regardless of the COM port settings elsewhere.
- "Continue CR after POST": Off (default), or On.
- Determines whether or not the system is to wait for a carriage return over the COM port before continuing (after POST is completed and before OS starts loading).
- Baud Rate: 19.2K (default), 300, 1200, 2400, 9600, 38.4K, 57.6K, 115.2K.
- Console Connection: Direct (default) or Modem.
- Console Type: PC ANSI (default), VT100, VT100 (8-bit), PC-ANSI (7-bit), VT100+, or VT-UTF8.
- Flow Control: CTS/RTS (default), XON-XOFF, None.
- Number of video Pages to support: 1(default) to 8.

  Note: Console Redirection only works for text-based interaction. If the OS enables video and starts using direct video functions (which would be the case with a Linux X-terminal or Windows, for example), Console Redirection has no effect and video is then required.

10. SYSTEM I/O

10.1 Ethernet

The Ethernet chip is the Intel 82574 and Topcliff integrated MAC.

The Hercules III Software CD includes Ethernet drivers for Windows XP, Windows CE, and Linux. The latest drivers can also be downloaded from National Semiconductor's website, listed in the Additional Information section of this document. (Search for "DP83815" to locate the product folder on the website).

A DOS utility program is provided for testing the chip and accessing the configuration EEPROM. Each board is factory-configured for a unique MAC address using this program. To run the program, boot the computer to DOS because the program will not run properly in a DOS window. In normal operation this program is not required.

Additional software support includes a packet driver with software to allow a full TCP/IP implementation.

10.2 Serial Ports

Hercules III contains six serial ports. Each port is capable of transmitting at speeds up to 115.2Kbaud. All ports are from the SCH3116 Super I/O chip.

The serial ports use the following default system resources.

Port	*I/O Address Range*	*IRQ*
COM1	0x3F8	4
COM2	0x2F8	3
COM3	0x3E8	4
COM4	0x2E8	3
COM4	0x100	4
COM4	0x108	3

The COM1 and COM2 settings may be changed in the system BIOS. Select the *Advanced* menu, followed by *I/O Device Configuration,* to modify the base address and interrupt level.

The addresses of COM3 and COM4 are fixed. The IRQ settings for COM3 and COM4 are selected using jumper block J10. COM3 can use IRQ3, IRQ4, IRQ5, IRQ6 or IRQ9, and COM4 can use IRQ3 or IRQ15.

Note: Once these jumper selections are made, the user must update the Serial Port IRQ settings to match these selections. The IRQ settings are NOT auto detected in the same way as the address settings.

10.3 USB Ports

Four USB 2.0 ports, USB0 through USB3, are accessible using cable assemblies attached to connectors J21 and J22. USB5 is available on J23.

USB support is intended primarily for the following devices (although any USB-standard device should function).

- Keyboard
- Mouse
- USB Floppy Drive (This is required for Crisis Recovery of boot ROM)
- USB flash disk

The BIOS supports the USB keyboard during BIOS initialization screens and legacy emulation for DOS-based applications.

The USB ports can be used for keyboard and mouse at the same time that the PS/2 keyboard and mouse are connected.

11. OPERATING SYSTEMS AND BOOTING PROCEDURES

11.1 Windows Operating System Installation Issues

Windows operating systems installation should follow these steps, or some device drivers may not function correctly under Windows.

1. Enable CD-ROM support in the BIOS. Change the boot sequence in the BIOS so the system boots from CD-ROM first.
2. Insert the Windows installation CD into the CD-ROM and restart the computer.
3. Follow the manufacturer's instructions for installing Windows.

11.1.1 Driver Installation

Drivers are provided on a CD. Please, follow the instructions included on the CD to install drivers for the different operating systems.

11.1.2 BIOS Setting for Windows

When using any version of Windows, the Operating System selection in the BIOS setup menus should be set to Win98. Also, *Legacy Audio* must be disabled for Windows to boot properly.

11.2 DOS Operating Systems Installation Issues

User the following sequence to install DOS operating systems: MS-DOS, FreeDOS and ROM-DOS.

1. Enable the following in BIOS:
    - Floppy Drive detection
    - Legacy USB support
2. Change the BIOS boot sequence so the system boots through the USB floppy drive.
3. Insert the DOS installation floppy disk into the USB floppy drive and start/restart the system.
4. Install any drivers needed.

    Note: For DOS Ethernet, set **Operating System** to **other** in the BIOS.

    Note: DOS Sound emulation is currently not functional.

12. DATA ACQUISITION CIRCUIT

Hercules III contains a data acquisition subsystem consisting of digital I/O (DIO), watchdog timer (WDC), counter/timer, pulse width modulation (PWM), and optional analog I/O features. The features of a board that includes data acquisition are equivalent to a complete PC/104 add-on data acquisition module.

The A/D section includes a 16-bit A/D converter, 32 input channels and a 2048-sample (4kByte) FIFO. Input ranges are programmable, and the maximum sampling rate is 250 KHz. The D/A section includes four 12-bit D/A channels. The digital I/O section includes 40 lines with programmable direction. The counter/timer section includes a 24-bit counter/timer to control A/D sampling rates and a 16-bit counter/timer for user applications. A 4-channel PWM controller provides a way to automatically generate PWM-based waveforms.

High-speed A/D sampling is supported with interrupts and a FIFO. The FIFO is used to store a user-selected number of samples, and an interrupt is generated when the FIFO reaches this threshold. Once the interrupt occurs, an interrupt service routine reads the data from the FIFO. In this way, the interrupt rate is reduced by a factor equal to the size of the FIFO threshold, enabling a faster A/D sampling rate. In DOS, or similar low-overhead OSs, the circuit can operate at sampling rates of up to 250 KHz.

The interrupt rate, when using high sample-rates, is kept low because of the large FIFO buffer. With a 250 kHz sampling rate and a FIFO threshold of 1024 samples (half-full), the interrupt rate is kept to a reasonable range of approximately 250Hz. Reducing the FIFO interrupt threshold increases the interrupt rate for a given sampling frequency, while increasing the threshold (especially the FIFO full threshold) increases the risk that samples may be lost because of interrupt latency. The interrupt rate is an issue under multitasking OSs, such as Windows, since interrupt handler latency can significant. For example, operating a serial port at maximum speed (115kbaud) can tax the resources of a system's latency periods, especially when such activity is talking place over the ISA bus, which is the case with both the serial ports and with the A/D FIFO. An interrupt rate of greater than 10 KHz can be difficult to sustain in Windows without losing samples.

The A/D circuit uses the default settings of I/O address range 0x240 – 0x25F (base address 0x240) and IRQ 5. The IRQ setting can be changed if needed using jumper J4.

The figure on the following page shows a block diagram of the data acquisition circuit.

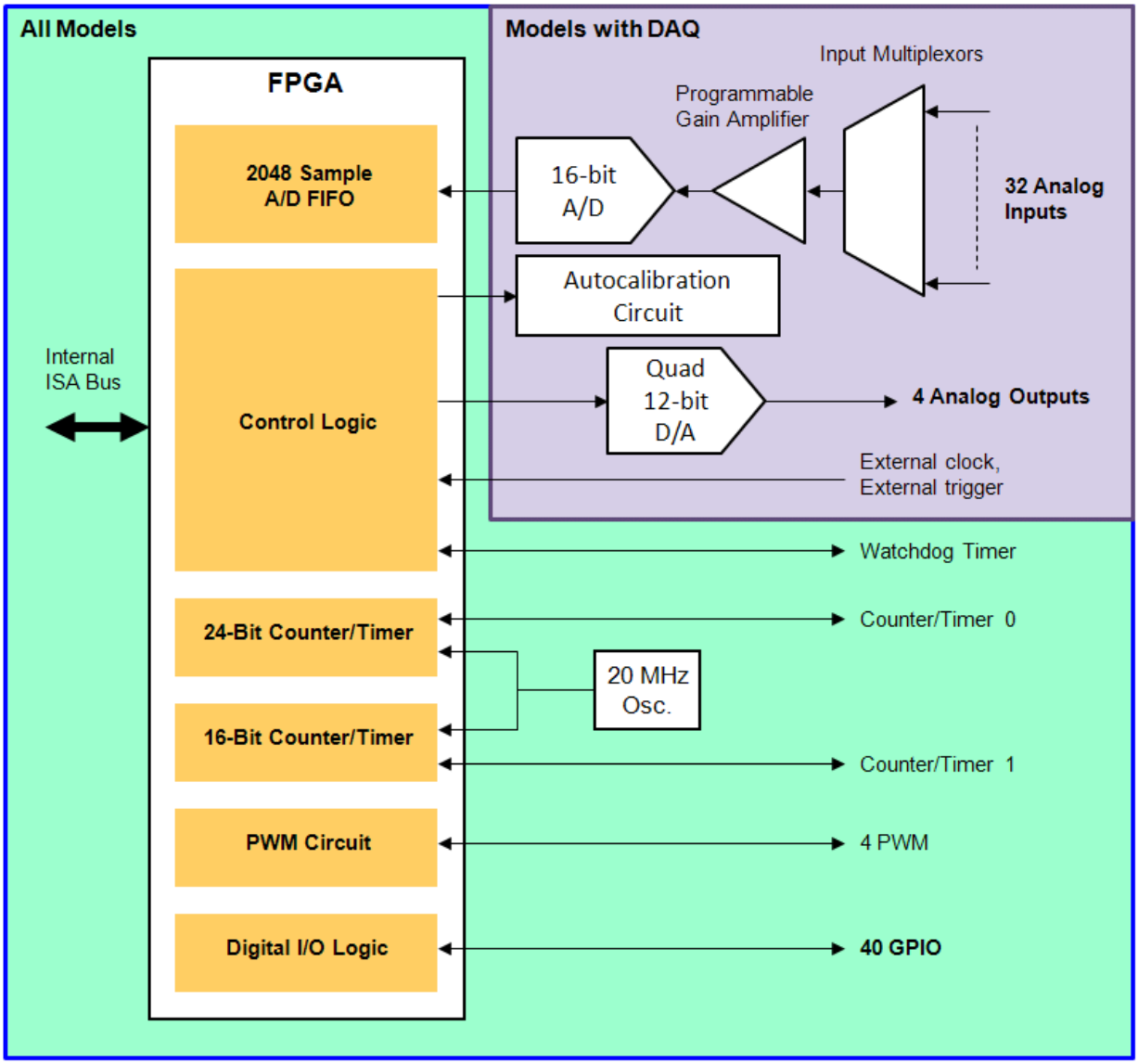


Figure 1: Data Acquisition Block Diagram

Data Acquisition Circuitry I/O Map

I/O Memory Space

The data acquisition circuitry on Hercules III occupies a block of 32 bytes in I/O memory space. The default address range for this block is 0x240 – 0x24F (base address 0x240).

The address range is a 32-byte block in ISA I/O Space. Within these 32-bytes, the registers are paged to provide full access to additional registers for additional functions; four pages (0-3) are available. Page is configured using the first register of the address space, located at the base address. Byte zero is always present and is mirrored across all four pages so the page register is always available.

The following tables list the register functions and base address offset, for each of the four pages.

Page 0		
Base +	***Write Function***	***Read Function***
0	Reset + page register	A/D LSB
1	Analog configuration register	A/D MSB
2	A/D low channel	A/D low channel readback
3	A/D high channel	A/D high channel readback
4	A/D range register	A/D range + status readback
5	D/A channel	-
6	D/A LSB	-
7	D/A MSB	-
8	FIFO threshold LSB	FIFO threshold LSB readback
9	FIFO threshold MSB	FIFO threshold MSB readback
10	-	FIFO depth LSB
11	-	FIFO depth MSB
12	Configuration register	Configuration register readback
13	Operation control register	Operation control register readback
14	-	Operation status register
15	Command register	Hardware config + A/D channel
16	DIO port A	DIO port A
17	DIO port B	DIO port B
18	DIO port C	DIO port C
19	DIO port D	DIO port D
20	DIO port E	DIO port E
21	-	-
22	DIO config / bit set	DIO config readback
23	-	-
24	Ctr/timer LSB	Ctr/timer LSB
25	Ctr/timer CSB	Ctr/timer CSB
26	Ctr/timer MSB	Ctr/timer MSB
27	Ctr command/configuration register	-
28	Watchdog timer A LSB	Watchdog timer A LSB
29	Watchdog timer A MSB	Watchdog timer A MSB
30	Watchdog timer B data	Watchdog timer B data
31	Watchdog configuration register	Watchdog config. register readback

Page 1		
Base +	***Write Function***	***Read Function***
24	PWM data register LSB	PWM data register LSB
25	PWM data register CSB	PWM data register CSB
26	PWM data register MSB	PWM data register MSB
27	PWM configuration register	-
28	(Autocal) EEPROM/TrimDAC Data	(Autocal) EEPROM/TrimDAC Data
29	(Autocal) EEPROM/TrimDAC	(Autocal) EEPROM/TrimDAC Address
30	(Autocal) Calibration Control register	(Autocal) Calibration Status register
31	(Autocal) EEPROM Access Key	FPGA Revision Code

Page 2		
Base +	***Write Function***	***Read Function***
24	D/A waveform (future)	Feature ID register – A/D
25	D/A waveform (future)	Feature ID register – D/A
26	D/A waveform (future)	Feature ID register – DIO
27	D/A waveform (future)	Feature ID register – Ctr/timers
28	D/A waveform (future)	Device ID register
29	D/A waveform (future)	Device ID register
30	-	-
31	-	-

Note: When pages 1 or 2 are enabled, the page 0 registers at addresses 0-23 are still accessible.

Page 3 is a 27-byte page occupying locations 1-27 of the chip, and contains a copyright notice in ASCII format.

In page 3, the RESET command and page register at base + 0 are accessible, so the chip may be reset or the page changed.

I/O Register Map Bit Assignments

Note: In the tables below, blank bits are not used. Writes to a blank bit have no effect. Reads of a blank bit return the value zero.

Page 0 Write

Base +	***7***	***6***	***5***	***4***	***3***	***2***	***1***	***0***
0	HOLDOFF	RESET	-	-	-	-	PAGE1	PAGE0
1	-	-	-	-	-	DABU	SEDIFF	ADBU
2	-	-	-	L4	L3	L2	L1	L0
3	-	-	-	H4	H3	H2	H1	H0
4	LDAD	-	-	-	-	-	G1	G0
5	SU	-	-	-	-	-	DACH1	DACH0
6	DA7	DA6	DA5	DA4	DA3	DA2	DA1	DA0
7	-	-	-	-	DA11	DA10	DA9	DA8
8	FT7	FT6	FT5	FT4	FT3	FT2	FT1	FT0
9	-	-	-	-	FT11	FT10	FT9	FT8
10	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-
12	LED	SINGLE	DIOCTR1	DIOCTR0	SCINT	CLKSRC1	CLKFRQ1	CLQFRQ0
13	-	TINTE	DINTE	AINTE	FIFOEN	SCANEN	CLKSEL	CLKEN
14	-	-	-	-	-	-	-	-
15	-	-	FIFORST	DARST	CLRT	CLRD	CLRA	ADSTART
16	DIOA7	DIOA6	DIOA5	DIOA4	DIOA3	DIOA2	DIOA1	DIOA0
17	DIOB7	DIOB6	DIOB5	DIOB4	DIOB3	DIOB2	DIOB1	DIOB0
18	DIOC7	DIOC6	DIOC5	DIOC4	DIOC3	DIOC2	DIOC1	DIOC0
19	DIOD7	DIOD6	DIOD5	DIOD4	DIOD3	DIOD2	DIOD1	DIOD0
20	DIOE7	DIOE6	DIOE5	DIOE4	DIOE3	DIOE2	DIOE1	DIOE0
21	-	-	-	-	-	-	-	-
22	MODE	P2	P1	PO/DIRE	B2/DIRD	B1/DIRC	B0/DIRB	D/DIRA
23	-	-	-	-	-	-	-	-
24	CTRD7	CTRD6	CTRD5	CTRD4	CTRD3	CTRD2	CTRD1	CTRD0
25	CTRD15	CTRD14	CTRD13	CTRD12	CTRD11	CTRD10	CTRD9	CTRD8
26	CTRD23	CTRD22	CTRD21	CTRD20	CTRD19	CTRD18	CTRD17	CTRD16
27	CTR	LATCH	CTDIS	GTEN	CTDIS	CTEN	LOAD	CLR
28	WDA7	WDA6	WDA5	WDA4	WDA3	WDA2	WDA1	WDA0
29	WDA15	WDA14	WDA13	WDA12	WDA11	WDA10	WDA9	WDA8
30	WDB7	WDB6	WDB5	WDB4	WDB3	WDB2	WDB1	WDB0
31	WDTRIG	-	WDEN	WDSMI	WDRST	WDT-1	WDEDGE	WDIEN

Page 0 Read

Base +	7	6	5	4	3	2	1	0
0	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0
1	AD15	AD14	AD13	AD12	AD11	AD10	AD9	AD8
2	-	-	-	L4	L3	L2	L1	L0
3	-	-	-	H4	H3	H2	H1	H0
4	ADBUSY	WAIT	DABUSY	DABU	SEDIFF	ADBU	G1	G0
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	FT7	FT6	FT5	FT4	FT3	FT2	FT1	FT0
9	-	-	-	-	FT11	FT10	FT9	FT8
10	FD7	FD6	FD5	FD4	FD3	FD2	FD1	FD0
11	-	-	-	FD12	FD11	FD10	FD9	FD8
12	LED	SINGLE	DIOCTR1	DIOCTR0	SCINT	CLKSRC1	CLKFRQ1	CLQFRQ
13	-	TINTE	DINTE	AINTE	FIFOEN	SCANEN	CLKSEL	CLKEN
14	-	TINT	DINT	AINT	OVF	FF	TF	EF
15	CFG1	CFG0	-	ADCH4	ADCH3	ADCH2	ADCH1	ADCH0
16	DIOA7	DIOA6	DIOA5	DIOA4	DIOA3	DIOA2	DIOA1	DIOA0
17	DIOB7	DIOB6	DIOB5	DIOB4	DIOB3	DIOB2	DIOB1	DIOB0
18	DIOC7	DIOC6	DIOC5	DIOC4	DIOC3	DIOC2	DIOC1	DIOC0
19	DIOD7	DIOD6	DIOD5	DIOD4	DIOD3	DIOD2	DIOD1	DIOD0
20	DIOE7	DIOE6	DIOE5	DIOE4	DIOE3	DIOE2	DIOE1	DIOE0
21	-	-	-	-	-	-	-	-
22	-	-	-	DIRE	DIRD	DIRC	DIRB	DIRA
23	-	-	-	-	-	-	-	-
24	CTRD7	CTRD6	CTRD5	CTRD4	CTRD3	CTRD2	CTRD1	CTRD0
25	CTRD15	CTRD14	CTRD13	CTRD12	CTRD11	CTRD10	CTRD9	CTRD8
26	CTRD23	CTRD22	CTRD21	CTRD20	CTRD19	CTRD18	CTRD17	CTRD16
27	-	-	-	-	-	-	-	-
28	WDA7	WDA6	WDA5	WDA4	WDA3	WDA2	WDA1	WDA0
29	WDA15	WDA14	WDA13	WDA12	WDA11	WDA10	WDA9	WDA8
30	WDB7	WDB6	WDB5	WDB4	WDB3	WDB2	WDB1	WDB0
31	-	-	-	-	-	-	-	-

Page 1 Write

Offsets base+28, +29 and +31 refer to EEPROM Data, address, and unlock command registers for auto-calibration.

Base +	7	6	5	4	3	2	1	0
0	HOLDOFF	RESET	-	-	-	-	PAGE1	PAGE0
24	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-
28	D7	D6	D5	D4	D3	D2	D1	D0
29	-	A6	A5	A4	A3	A2	A1	A0
30	EE_EN	EE_RW	RUNCAL	CMUXEN	TDACEN	-	-	-
31	-	-	-	-	-	-	-	-

Page 1 Read

Offset base+31 is the FPGA revision code (0x40).

Base +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	-	-
24	PWMD7	PWMD6	PWMD5	PWMD4	PWMD3	PWMD2	PWMD1	PWMD0
25	PWMD15	PWMD14	PWMD13	PWMD12	PWMD11	PWMD10	PWMD9	PWMD8
26	PWMD23	PWMD22	PWMD21	PWMD20	PWMD19	PWMD18	PWMD17	PWMD16
27	-	-	-	-	-	-	-	-
28	D7	D6	D5	D4	D3	D2	D1	D0
29	-	A6	A5	A4	A3	A2	A1	A0
30	0	TDBUSE	EEBUSY	CMUXEN	0	0	0	0
31	-	-	-	-	-	-	-	-

Page 2 Write

Offsets base+24 through base+31 are reserved for a future D/A waveform generator circuit.

Base +	7	6	5	4	3	2	1	0
0	HOLDOFF	RESET	-	-	-	-	PAGE1	PAGE0
24	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-

Page 2 Read

Base +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	-	-
24	ADQ7	ADQ6	ADQ5	ADQ4	ADQ3	ADQ2	ADQ1	ADQ0
25	FDID2	FDID1	FDID0	DAQ4	DAQ3	DAQ2	DAQ1	DAQ0
26	DIOQ7	DIOQ6	DIOQ5	DIOQ4	DIOQ3	DIOQ2	DIOQ1	DIOQ0
27	PWMQ3	PWMQ2	PWMQ1	PWMQ0	CTRQ3	CTRQ2	CTRQ1	CTRQ0
28	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0
29	ID15	ID14	ID13	ID12	ID11	ID10	ID9	ID8
30	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-

I/O Register Definitions

Page 0 Register Definitions

Page Select and Reset Command: Base+0 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	HOLDOFF	RESET	-	-	-	-	PAGE	

HOLDOFF When this bit is set, the chip ignores any data written to this register. This bit enables shadowing this register with another device at the same address.

RESET Reset the entire data acquisition circuit. After a reset, the following conditions are true:

1. Digital I/O ports are set to input mode and all output registers are cleared to 0.
2. A/D channel registers and range settings are cleared to zero, except for the Analog Configuration Register (Base+1) which is set to 0x04.
3. D/A channels are cleared to mid-scale or zero-scale, depending on the board jumper setting.
4. Counter/timers are disabled and counter registers are cleared to zero.
5. Watchdog timer is disabled and timer registers are cleared to zero.
6. FIFO is reset, causing all contents to be lost, and threshold is set to 1024 samples.
7. The internal channel / gain table is reset to all zeros.

PAGE Select page.

0 = Main features page
1 = Extended features page
2 = ID page
3 = Copyright notice page

A/D LSB: Base+0 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0

AD7-AD0 A/D LSB data. The A/D data must be read LSB first, followed by MSB.

Analog Configuration: Base+1 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	-	-	-	-	-	DABU	SEDIFF	ADBU

DABU D/A output range: 0 = bipolar, 1 = unipolar. (Default on reset is unipolar mode).

SEDIFF A/D mode: 0 = single-ended, 1 = differential.

ADBU A/D input range: 0 = bipolar, 1 = unipolar.

A/D MSB: Base+1 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	AD15	AD14	AD13	AD12	AD11	AD10	AD9	AD8

AD15-AD8 A/D MSB data. The A/D data must be read LSB first, followed by MSB.

A/D Low Channel: Base+2 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	-	-	-	L4	L3	L2	L1	L0

L4-L0 A/D low channel number.

A/D High Channel: Base+3 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	-	-	-	H4	H3	H2	H1	H0

H4-H0 A/D high channel number.

A/D Input Range Control: Base+4 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	LDAD	-	-	-	-	-	G(1/0)	

LDAD The FPGA contains a global input range setting as well as a 32x4 table for all 32 input channels that can be used for individual input ranges, for each channel. The chip uses either the global input range setting or the individual range table, based on the setting of the SINGLE bit in register Base+12.

If this bit is set (1), the remaining bits are stored as the individual input range for the A/D channel currently set by L4-L0 in register Base+2. If this bit is reset (0), the remaining bits are the global setting for all input channels.

G(1/0) Gain: The gain is the ratio between the input voltage and the voltage seen by the A/D converter. The A/D always works with a maximum input voltage of 10V. A gain of 2 means the maximum input voltage at the connector pin is 5V.

0 = gain of 1
1 = gain of 2
2 = gain of 4
3 = gain of 8

A/D Range/Status Readback: Base+4 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	ADBUSY	WAIT	DABUSY	DABU	SEDIFF	ADBU	G(1/0)	

ADBUSY 0 = A/D is idle and data may be read out.
1 = A/D is performing an A/D conversion.

WAIT 0 = A/D circuit is ready to perform an A/D conversion.
1 = A/D circuit is settling on a new channel or gain setting. The program must not initiate an A/D conversion while WAIT = 1.

DABUSY 0 = D/A circuit is idle / D/A output is stable.
1 = D/A circuit is transferring data to the D/A chip after writing data to the board.

DABU 0 = bipolar.
1 = unipolar D/A output range.

SEDIFF 0 = single-ended.
1 = differential A/D mode.

ADBU 0 = bipolar.
1 = unipolar A/D input range.

G(1/0) Readback of global A/D gain setting. The individual A/D gain settings may not be read back.

D/A Channel: Base+5 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	SU	-	-	-	-	-	DACH(1/0)	

SU Simultaneous Update:
0 = Transparent (written directly to the DAC's)/Simultaneous write.
1 = Latch and hold data (DAC output not updated until "0" is written later).

DACH(1/0) D/A channel number.

Note: Writing to this register updates the selected D/A channel with the data currently stored in registers Base+6 and Base+7. The high-order bit determines if the data is transferred directly out to the DAC's (transparent mode) or is latched and held for a later simultaneous update.

D/A LSB: Base+6 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	DA7-DA0							

DA7-DA0 D/A LSB data.

D/A MSB: Base+7 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	DA15-DA8							

DA15-DA8 D/A MSB data.

FIFO Threshold LSB: Base+8 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	FT7-FT0							

FT7-FT0 FIFO threshold value LSB.

FIFO Threshold MSB: Base+9 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	-	-	-	-	-	FT10-FT8		

FT10-FT8 FIFO threshold value MSB.

When the FIFO depth is greater than or equal to the FIFO threshold, TF (threshold flag) = 1 and an A/D interrupt request will be generated, if FIFOEN = 1 and ADINTE = 1.

The FIFO size is 2048 samples. The threshold value may be anywhere from 1 to 2047 samples. In most cases, the threshold does not need to be larger than one-half the FIFO size, or 1024 samples.

On power-up or system reset, the FIFO threshold is set to 1024 samples.

FIFO Depth LSB: Base+10 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	FD7-FD0							

FD7-FD0 Current FIFO depth LSB.

FIFO Depth MSB: Base+11 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	-	-	-	FD12-FD8				

FD12-FD8 Current FIFO depth MSB.

The FIFO depth registers indicates the current depth, or number of bytes, in the FIFO. The depth is reset to 0 when a FIFORST command occurs. It increments by one each time a byte from the A/D converter is inserted into the FIFO and decrements by one each time a byte is read from the FIFO. FD, therefore, increments/decrements by two for a full A/D sample write or read operation. If a 16-bit read operation occurs, FD decrements by 2 after the operation.

Configuration: Base+12 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	LED	SINGLE	DIOCTR1	DIOCTR0	SCINT	CLKSRC1	CLKFRQ1	CLKFRQ0

LED Active high, a simple status bit used to drive external LED. Default is high upon power-up.

SINGLE Indicates whether to use the global A/D input range or the individual input range table for A/D conversions.
- 0 = use global setting for all channels.
- 1 = use the programmed settings for each channel.

DIOCTR1 I/O connector DIOE7-4 pins signal selection:
- 0 = digital I/O lines DIOE7-4 appear on DIOE7-4 pins of I/O connectors.
- 1 = counter signals appear on DIOE7-4 pins of I/O connectors.

DIOCTR0 I/O connector DIOE3-0 pins signal selection:
- 0 = digital I/O lines DIOE3-0 appear on DIOE3-0 pins of I/O connectors.
- 1 = PWM signals appear on DIOE3-0 pins of I/O connectors.

SCINT A/D scan interval selection:
- 0 = 4µS
- 1 = 9µS

CLKSRC1 Clock source for counter 1:
- 0 = internal (see CLKFRQ1 below).
- 1 = external (J8, pin 41, EXTTRIG).

CLKFRQ1 Internal clock frequency for counter 1:
- 0 = 10MHz
- 1 = 100 KHz

CLKFRQ0 Internal clock frequency for counter 0:
- 0 = 10MHz
- 1 = 100 KHz

Operation Control: Base+13 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:		TINTE	DINTE	AINTE	FIFOEN	SCANEN	CLKSEL	CLKEN

TINTE Timer interrupt enable (Only one of the TINTE/DINTE/AINTE interrupts may be enabled at a time):

0 = disabled

1 = enabled

DINTE Digital I/O interrupt enable (Only one of the TINTE/DINTE/AINTE interrupts may be enabled at a time):

0 = disabled

1 = enabled

AINTE A/D interrupt enable (Only one of the TINTE/DINTE/AINTE interrupts may be enabled at a time):

0 = disabled

1 = enabled

FIFOEN FIFO enable. When the FIFOEN = 1 and AINTE = 1, A/D interrupts occur when the FIFO reaches its programmed threshold set with FT11-0. When FIFOEN = 0 and AINTE = 1, A/D interrupts occur according to the following conditions: a) if SCANEN = 1, the interrupt occurs at the end of the scan, and the FIFO contains all the samples of the scan; b) if SCANEN = 0, the interrupt occurs after each single A/D conversion.

0 = disabled

1 = enabled

SCANEN A/D Scan enable. When SCANEN = 1, the A/D circuit performs a complete scan of all channels between the low and high channels, inclusive, with each trigger.

0 = disabled

1 = enabled

CLKSEL A/D hardware clock select (only applies when CLKEN = 1):

0 = rising edge of counter/timer 0.

1 = falling edge on external trigger from I/O connector.

CLKEN A/D hardware clock enable. When CLKEN = 1, the A/D circuit is triggered by the hardware clock selected with CLKSEL above, and the software A/D trigger is disabled.

0 = disabled

1 = enabled

Operation Status: Base+14 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	-	TINT	DINT	AINT	OVF	FF	TF	EF

TINT Timer interrupt status:
1 = interrupt pending
0 = no interrupt pending

DINT Digital I/O interrupt status:
1 = interrupt pending
0 = no interrupt pending

AINT A/D interrupt status:
1 = interrupt pending
0 = no interrupt pending

OVF FIFO overflow flag. Overflow occurs when the FIFO is full and an A/D conversion occurs. If OVF is set, it will stay set until the FIFO is reset with a FIFORST command.
0 = no overflow
1 = overflow

FF FIFO full flag:
0 = FIFO is not full
1 = FIFO is full

TF FIFO threshold flag:
0 = FIFO depth is below the programmed threshold
1 = FIFO depth is at or above the programmed threshold

EF FIFO empty flag:
0 = not empty
1 = empty

Command: Base+15 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	-	-	FIFORST	DARST	CLRT	CLRD	CLRA	ADSTART

FIFORST Reset the FIFO. After this command, OVF, FF, and TF = 0, and EF = 1.

DARST Reset the D/A. All D/A channels are reset to zero-scale.

CLRT Clear timer interrupt request.

CLRD Clear digital I/O interrupt request.

CLRA Clear A/D interrupt request.

ADSTART Start an A/D conversion. After this command, ADBUSY = 1, until the A/D conversion is finished.

Each bit in this register represents a command. Writing a 1 to any bit executes the command specified by that bit. Only one bit may be written at a time.

Hardware Configuration and A/D Channel Readback: Base+15 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	CFG(1/0)		-	ADCH4-0				

CFG(1/0) These bits report the logic level of two input pins on the logic chip that can be used to indicate the board's hardware configuration. The current, default value is "11".

ADCH4-0 Current A/D channel. This is the channel sampled on the next A/D conversion.

Digital I/O Port A: Base+16 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	DIOA7-0							

DIOA7-0 Port A DIO data.

Digital I/O Port B: Base+17 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	DIOB7-0							

DIOB7-0 Port B DIO data.

Digital I/O Port C: Base+18 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	DIOC7-0							

DIOC7-0 Port C DIO data.

Digital I/O Port D: Base+19 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	DIOD7-0							

DIOD7-0 Port D DIO data.

Digital I/O Port E: Base+20 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	DIOE7-0							

DIOE7-0 Port E DIO data. Port E shares device pins with 4 counter/timer signals and 4 PWM outputs. The function of these two groups of four pins is controlled with register bits DIOCTR1 and DIOCTR0.

DIOCTR1:

0 = digital I/O lines DIOE7-4 appear on DIOE7-4 pins of I/O connectors.

1 = counter signals appear on DIOE7-4 pins of I/O connectors.

DIOCTR0:

0 = digital I/O lines DIOE3-0 appear on DIOE3-0 pins of I/O connectors.

1 = PWM signals appear on DIOE3-0 pins of I/O connectors.

(See register Base+12, Configuration Register, for details).

Digital I/O Configuration / Bit Programming: Base+22 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	MODE	P2-P0			B2-B0			D
		-	-	DIRE-A				

MODE Indicates port direction or bit programming mode:

0 = port direction; used to configure the direction of the digital I/O ports.

1 = bit programming; provides a quick way to program individual digital I/O bits.

P2-P0 (MODE = 0)

Port number:

0 = A

1 = B

2 = C

3 = D

B2-B0 (MODE = 0)

Bit number, 0-7.

D (MODE = 0)

Bit value, 0 or 1.

DIRE-A (MODE = 1)

Direction for ports A – E. On power-up or system reset, all ports are set to input mode and the contents of the output registers are set to 0.

0 = input

1 = output

Note: Counter/timer 0 is 24 bits wide and uses all three of the following registers. Counter/timer 1 is 16 bits wide and uses only registers 24 and 25. The bytes may be written and read in any order.

Counter/Timer Data Byte 1: Base+24 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	CTRD7-0							

CTRD7-0 LSB for counter/timers 0 and 1.

Counter/Timer Data Byte 2: Base+25 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	CTRD15-8							

CTRD15-8 CSB (middle byte) for counter/timer 0, MSB for counter/timer 1.

Counter/Timer Data Byte 3: Base+26 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	CTRD23-16							

CTRD23-16 MSB for counter/timer 0.

Counter/Timer Control: Base+27 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	CTR	LATCH	GTDIS	GTEN	CTDIS	CTEN	LOAD	CLEAR

CTR	Counter number, 0 or 1.
LATCDH	Latch selected counter's current data into bytes 1-3 or 1-2, as appropriate.
GTDIS	Disable gating on selected counter.
GTEN	Enable gating on selected counter.
CTDIS	Disable counting on selected counter.
CTEN	Enable counting on selected counter.
LOAD	Load selected counter with data in bytes 1-3 or 1-2, as appropriate.
CLEAR	Clear selected counter to zero.

Watchdog Timer A LSB Data: Base+28 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	WDA7-0							

WDA7-0 LSB of timer A divisor. Loading occurs for both bytes when the MSB is written.

Watchdog Timer A MSB Data: Base+29 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	WDA15-8							

WDA15-8 MSB of timer A divisor. Loading occurs for both bytes when the MSB is written.

Watchdog Timer B Data: Base+30 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	WDB7-0							

WDB7-0 Watchdog timer B data register. Loading occurs immediately upon writing to this register.

Watchdog Timer Configuration: Base+31 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	WDTRIG	-	WDEN	WDSMI	WDRST	WDT-1	WDEDGE	WDIEN

WDTRIG If this bit is set (1), the remaining bits of this register are ignored and, instead, watchdog timer A is retriggered; i.e. reloaded with its initial value. If this bit is reset (0), the remaining bits in this register are used to configure the watchdog timer circuit.

WDEN Enable watchdog timer circuit:
0 = disabled
1 = enabled

WDSMI Enable SMI interrupt upon watchdog timer timeout.

WDRST Enable system reset upon watchdog timer timeout (setting this clears WDSMI).

WDT-1 Enable output pulse from timer A 1 clock early on WDO pin of I/O connectors. This allows WDO to be connected to WDI to prevent watchdog timer timeout as long as the timer is running.

WDEDGE Select active edge for hardware (external) retrigger:
0 = rising edge.
1 = falling edge.

WDIEN Enable external input hardware watchdog trigger instead of on-board software trigger.
0 = internal trigger only.
1 = external trigger plus internal trigger are enabled.

Page 1 Register Definitions

Page Select and Reset Command: Base+0 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	HOLDOFF	RESET	-	-	-	-	PAGE	

HOLDOFF When this bit is set, the chip ignores any data written to this register. This bit enables shadowing this register with another device at the same address.

RESET Reset the entire data acquisition circuit. After a reset, the following conditions are true:

1. Digital I/O ports are set to input mode and all output registers are cleared to 0.
2. A/D channel registers and range settings are cleared to zero, except for the Analog Configuration Register (Base+1) which is set to 0x04.
3. D/A channels are cleared to mid-scale or zero-scale, depending on the board jumper setting.
4. Counter/timers are disabled and counter registers are cleared to zero.
5. Watchdog timer is disabled and timer registers are cleared to zero.
6. FIFO is reset, causing all contents to be lost, and threshold is set to 1024 samples.
7. The internal channel / gain table is reset to all zeros.

PAGE Select page.

0 = Main features page
1 = Extended features page
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3 = Copyright notice page

PWM Data LSB: Base+24 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	PWMD7-0							

PWMD7-0 PWM data bits 7-0.

PWM Data CSB: Base+25 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	PWMD15-8							

PWMD15-8 PWM data bits 15-8.

PWM Data MSB: Base+26 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	PWMD23-16							

PWMD23-16 PWM data bits 23-16.

PWM Command: Base+27 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	FLAG	RSVD	PWM(1/0)		0/CLK	0/POL	0/OUTEN	CTR/ENA

FLAG Command/configuration flag:
0 = command
1 = configuration

RSVD (reserved for future use)

PWM(1/0) Indicates which of the four PWM circuits to access.

CLK If FLAG = 0, value of bits 1-3 are zero, which is the load counter command.
If FLAG = 1, selects internal clock source for both PWM counters:
0 = 10MHz
1 = 100 KHz

POL If FLAG = 0, value of bits 1-3 are zero, which is the load counter command.
If FLAG = 1, selects polarity of output pulse (active level):
0 = active low level
1 = active high level

OUTEN If FLAG = 0, value of bits 1-3 are zero, which is the load counter command.
If FLAG = 1, output enable:
0 = disabled (output held at inactive level based on setting of POL bit)
1 = enabled

CTR/ENA If FLAG = 0, indicates which counter to act on:
0 = rate counter.
1 = duty cycle counter.
If FLAG = 1,
0 = disabled
1 = running

EEPROM/TrimDAC Data: Base+28 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	D7-0							

D7-0 Calibration data to be read or written to the EEPROM and/or TrimDAC. During EEPROM or TrimDAC *write* operations, the data written to this register is written to the selected device. During EEPROM *read* operations this register contains the data read from the EEPROM, which is valid only after EEBUSY = 0.

The EEPROM data can be read and written. The TrimDAC data can only be written.

EEPROM / TrimDAC Address: Base+29 (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	A7-0							

A7-0 EEPROM / TrimDAC address. The EEPROM recognizes address 0 – 255 using address bits A7 – A0. The TrimDAC recognizes addresses 0 – 7 using bits A2 – A0. In each case, unused address bits are ignored.

Current implementations of FPGA/Data Acquisition storage only use the lower 128 bytes of EEPROM data (addresses 0-127). The remaining 128 bytes (addresses 128-255) are available for general use.

Calibration Control: Base+30 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	EE_EN	EE_RW	RUNCAL	CMUXEN	TDACEN	-	-	-

EE_EN EEPROM Enable. Setting this bit initiates a transfer to/from the EEPROM; the direction is indicated by the EE_RW bit. However if TDACEN is set simultaneously, EE_EN is ignored.

EE_RW Selects read or write operation for the EEPROM:

0 = Write

1 = Read

RUNCAL Setting this bit causes the board to reload the calibration settings from EEPROM registers 0-7 into the eight TrimDACs. which is equivalent to a “reload” operation. During reload operation, TDBUSY = 1.

CMUXEN Calibration multiplexer enable. The CMUXEN bit is used to enable calibration mode. After calibration is complete, CMUXEN is reset and the desired configuration is restored. The calibration multiplexer is used to read precision on-board reference voltages that are used in the auto-calibration process. It also can be used to read the value of analog output 0.

0 = disable calibration multiplexer, enable user inputs.

1 = enable calibration multiplexer and disable user analog input channels/muxes.

TDACEN TrimDAC Enable. Setting this bit will initiates a transfer to the TrimDAC. This bit overrides the EE_EN setting; if both bits are set simultaneously, EE_EN is ignored.

Calibration Status: Base+30 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	0	TDBUSY	EEBUSY	CMUXEN	0	0	0	0

TDBUSY TrimDAC busy indicator:
0 = User may access TrimDAC.
1 = TrimDAC is being accessed or reload operation is in progress.

EEBUSY EEPROM busy indicator:
0 = User may access EEPROM.
1 = EEPROM is being accessed.

CMUXEN Calibration multiplexer enable status.
0 = disabled
1 = enabled

Note: When either TDBUSY or EEBUSY is set, do not access the data and address registers at Base+12 and Base+13.

EEPROM Access Key: Base+31 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	EEPROM Access Key							

EEPROM Access Key: To access the EEPROM, write the value 0xA5 (10100101) to this register each time, after setting the PAGE bit in order. This helps prevent accidental corruption of EEPROM contents.

FPGA Revision Code: Base+31 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	FPGA Revision Code							

FPGA Revision Code: This register indicates the revision number of the FPGA design. The current revision code is 0x40.

Page Select and Reset Command: Base+0 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	HOLDOFF	RESET	-	-	-	-	PAGE	

HOLDOFF When this bit is set, the chip ignores any data written to this register. This bit enables shadowing this register with another device at the same address.

RESET Reset the entire data acquisition circuit. After a reset, the following conditions are true:

1. Digital I/O ports are set to input mode and all output registers are cleared to 0.
2. A/D channel registers and range settings are cleared to zero, except for the Analog Configuration Register (Base+1) which is set to 0x04.
3. D/A channels are cleared to mid-scale or zero-scale, depending on the board jumper setting.
4. Counter/timers are disabled and counter registers are cleared to zero.
5. Watchdog timer is disabled and timer registers are cleared to zero.
6. FIFO is reset, causing all contents to be lost, and threshold is set to 1024 samples.
7. The internal channel / gain table is reset to all zeros.

PAGE Select page.

0 = Main features page
1 = Extended features page
2 = ID page
3 = Copyright notice page

A/D Feature ID: Base+24 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	ADQ7-0							

ADQ7-0 Indicates the number of A/D channels available on the board.

D/A Feature ID & FIFO Depth ID: Base+25 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	FDID2-0			DAQ4-0				

FDID2-0 Indicates the maximum sample depth supported by the FPGA FIFO. Currently, a value of "001" is defined, which describes a FIFO depth of 2048 samples.

DAQ4-0 Indicates the number of D/A channels available on the board.

Digital I/O Feature ID: Base+26 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	DIOQ7-0							

DIOQ7-0 Indicates the number of DIO pins available on the board.

PWM and Ctr/Timer Feature ID: Base+27 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	PWMQ3-0				CTRQ3-0			

PWMQ3-0 Indicates the number of PWM channels available on he board.

CTRQ3-0 Indicates the number of counter/timers available on the board.

Chip ID LSB: Base+28 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	ID7-0							

ID7-0 (See Chip ID MSB: Base+29, below)

Chip ID MSB: Base+29 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	ID15	ID14-8						

ID15 Prototype/released board indicator:

0 = Prototype/unreleased version.

1 = Released design.

ID14-8 Together with Chip ID LSB: Base+28, indicates the unique chip ID according to a (TBD) format. Each revision of the chip contains a unique 16-bit ID to enable software to distinguish between different board versions. The current chip ID should be 0x8000 or higher.

Page Select and Reset Command: Base+0 (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	HOLDOFF	RESET	-	-	-	-	PAGE	

HOLDOFF When this bit is set, the chip ignores any data written to this register. This bit enables shadowing this register with another device at the same address.

RESET Reset the entire data acquisition circuit. After a reset, the following conditions are true:

1. Digital I/O ports are set to input mode and all output registers are cleared to 0.
2. A/D channel registers and range settings are cleared to zero, except for the Analog Configuration Register (Base+1) which is set to 0x04.
3. D/A channels are cleared to mid-scale or zero-scale, depending on the board jumper setting.
4. Counter/timers are disabled and counter registers are cleared to zero.
5. Watchdog timer is disabled and timer registers are cleared to zero.
6. FIFO is reset, causing all contents to be lost, and threshold is set to 1024 samples.
7. The internal channel / gain table is reset to all zeros.

PAGE Select page.

0 = Main features page
1 = Extended features page
2 = ID page
3 = Copyright notice page

Copyright Notice: Base+1 to Base+31 (Read)

Bit:	7	6	5	4	3	2	1	0
Name:	Copyright Notice Text							

Copyright Notice Text 31 bytes of 8-bit ASCII-formatted copyright notice text.

13. ANALOG-TO-DIGITAL INPUT RANGES AND RESOLUTION

13.1 Overview

Hercules III uses a 16-bit A/D converter. The full range of numerical values for a 16-bit number is 0 - 65535. However, the A/D converter uses two's complement notation, so the A/D value is interpreted as a signed integer, ranging from –32768 to +32767.

The smallest change in input voltage that can be detected is 1/(216), or 1/65536, of the full-scale input range. This smallest change results in an increase or decrease of 1 in the A/D code, and is referred to as 1 LSB (1 Least Significant Bit).

The analog inputs on Hercules III have three configuration options.

- Single-ended or differential mode
- Unipolar or bipolar mode
- Input range (gain)

The single-ended/differential and unipolar/bipolar modes are configured using software.

13.1.1 Input Range Selection

You can select a gain setting for the inputs, which causes them to be amplified before they reach the A/D converter. The gain setting is controlled in software, which allows it to be changed on a channel-by-channel basis. In general, you should select the highest gain (smallest input range) that allows the A/D converter to read the full range of voltages over which the input signals will vary. However, a gain that is too high causes the A/D converter to clip at either the high end or low end, and you will not be able to read the full range of voltages on your input signals.

13.1.2 Input Range Table

The table below indicates the analog input range for each possible configuration. The gain is set with the G1 and G0 bits in the register at Base+3. The Gain value in the table is provided for clarity. Note that the single-ended vs. differential setting has no impact on the input range or the resolution.

Polarity	*G1*	*G0*	*Input Range*	*Resolution 1LSB*
Bipolar	0	0	±10V	305µV
Bipolar	0	1	±5V	153µV
Bipolar	1	0	±2.5V	76µV
Bipolar	1	1	±1.25V	38µV
Unipolar	0	0	Invalid	Invalid
Unipolar	0	1	0 - 10V	153µV
Unipolar	1	0	0 - 5V	76µV
Unipolar	1	1	0 - 2.5V	38µV

14. PERFORMING AN A/D CONVERSION

14.1 Introduction

This chapter describes the steps involved in performing an A/D conversion on a selected input channel using direct programming (without the driver software). Perform an A/D conversion according to the following steps, each step is discussed in detail below.

5. Select the input channel.
6. Select the input range.
7. Wait for analog input circuit to settle.
8. Initiate an A/D conversion.
9. Wait for the conversion to finish.
10. Read the data from the board.
11. Convert the numerical data to a meaningful value.

14.2 Select the Input Channel

To select the input channel to read, write a low-channel/high-channel pair to the channel register at Base+2. The low four bits select the low channel, and the high four bits select the high channel. When you write any value to this register, the current A/D channel is set to the low channel.

For example, to set the board to channel 4 only, write 0x44 to Base+2). To set the board to read channels 0 through 15, write 0xF0 to Base+2.

When you perform an A/D conversion, the current channel automatically increments to the next channel in the selected range. Therefore, to perform A/D conversions on a group of consecutively-numbered channels, you do not need to write the input channel prior to each conversion. For example, to read from channels 0 - 2, write 0x20 to base+2. The first conversion is on channel 0, the second will be on channel 1 and the third will be on channel 2. The channel counter wraps around to the beginning so the fourth conversion will be on channel 0, again.

If you are sampling the same channel repeatedly, set both high and low to the same value as in the first example, above. On subsequent conversions, you do not need to set the channel again.

14.3 Select the Input Range

Select the input range from among the available ranges. If the range is the same as for the previous A/D conversion it does not need to be set again. Write this value to the input range register at Base+3.

For example, for ±5V range (gain of 2), write 0x01 to Base+3.

14.4 Wait for Analog Input Circuit to Settle

After writing to either the channel register, Base+2, or the input range register, Base+3, allow time for the analog input circuit to settle before starting an A/D conversion. The board has a built-in 10µS timer to assist with the wait period. Monitor the WAIT bit at Base+3, bit 5. When the bit value is 1, the circuit is actively settling on the input signal. When the value is 0, the board is ready to perform A/D conversions.

14.5 Perform an A/D Conversion on the Current Channel

After the above steps are completed, start the A/D conversion by writing to Base+0. This write operation only triggers the A/D if AINTE = 0 (interrupts are disabled). When AINTE = 1, the A/D can only be triggered by the on-board counter/timer or an external signal. This protects against accidental triggering by software during a long-running interrupt-based acquisition process.

```
outp(base,0x80);
```

14.6 Wait for the Conversion to Finish

The A/D converter chip takes up to five microseconds to complete one A/D conversion. Most processors and software can operate fast enough so that if you try to read the A/D converter immediately after starting the conversion, the read will occur faster than the A/D conversion and return invalid data. Therefore, the A/D converter provides a status signal to indicate whether it is busy or idle. This bit can be read back from the status register at Base+3, bit 7. When the A/D converter is busy (performing an A/D conversion), the bit value is 1 and the program must wait. When the A/D converter is idle (conversion is done and data is available), this bit value is 0 and the program may read the data.

The following statement is a simple example of this operation.

```
while (inp(base+3) & 0x80);  // Wait for conversion to finish before proceeding
```

The above example could hang your program if there is a hardware fault and the bit is stuck at 1. A better solution is to use a loop with a timeout, as shown below.

```
int checkstatus()    // returns 0 if ok, -1 if error
int i;
for (i = 0; i < 10000; i++)
{
       if !(inp(base+3) & 0x80) then return(0);       // conversion completed
}
return(-1);                                           // conversion did not complete
```

14.7 Read the Data from the Board

Once the conversion is complete, you can read the data back from the A/D converter. The data is a 16-bit value and is read back in two 8-bit bytes. The LSB must be read from the board before the MSB because the data is inserted into the board's FIFO in that order. Unlike other registers on the board, the A/D data may only be read one time, because each time a byte is read from the FIFO the internal FIFO pointer advances and that byte is no longer available. Reading data from an empty FIFO returns unpredictable results.

The following pseudo-code illustrates how to read and construct the 16-bit A/D value.

```
LSB = inp(base);
MSB = inp(base+1);
Data = MSB * 256 + LSB;   // combine the 2 bytes into a 16-bit value
```

The final data are interpreted as a 16-bit signed integer in the range -32768 to +32767.

> **Note:** The data range always includes both positive and negative values, even if the board is set to a unipolar input range. The data must now be converted to volts or other engineering units by using a conversion formula, as discussed below.

In scan mode, the behavior is the same except when the program initiates a conversion, all channels in the programmed channel range will be sampled once and the data will be stored in the FIFO. The FIFO depth register increments by the scan size. When STS goes low, the program should read out the data for all channels.

14.8 Convert the numerical data to a meaningful value

Once the A/D value is read, it needs to be converted to a meaningful value. The first step is to convert it back to the actual measured voltage. Afterwards, you may need to convert the voltage to some other engineering units. For example, the voltage may come from a temperature sensor and the voltage would then need to be converted to the corresponding temperature, according to the temperature sensor's characteristics.

Since there are a large number of possible input devices, this secondary step is not included here. Only conversion to input voltage is described. However, you can combine both transformations into a single formula if desired.

To convert the A/D value to the corresponding input voltage, use the following formulas.

14.8.1 Conversion Formula for Bipolar Input Ranges

Input voltage = A/D value / 32768 * Full-scale input range

Example:

Given, Input range is ±5V and A/D value is 17761.

Therefore,

Input voltage = 17761 / 32768 * 5V = 2.710V.

For a bipolar input range,

1 LSB = 1/32768 * Full-scale voltage.

The table, below, shows the relationship between A/D code and input voltage for a bipolar input range (VFS = Full scale input voltage).

A/D Code	*Input Voltage Symbolic Formula*	*Input Voltage for ±5V Range*
-32768	$-V_{FS}$	-5.0000V
-32767	$-V_{FS}$ + 1 LSB	-4.9998V
...	...	...
-1	-1 LSB	-0.00015V
0	0	0.0000V
1	+1 LSB	0.00015V
...	...	...
32767	V_{FS} - 1 LSB	4.9998V

14.8.2 Conversion Formula for Unipolar Input Ranges

Input voltage = (A/D value + 32768) / 65536 * Full-scale input range

Example:

Given, Input range is 0-5V and A/D value is 17761.

Therefore,

Input voltage = (17761 + 32768) / 65536 * 5V = 3.855V.

For a unipolar input range, 1 LSB = 1/65536 * Full-scale voltage.

The following table illustrates the relationship between A/D code and input voltage for a unipolar input range (VFS = Full scale input voltage).

A/D Code	*Input Voltage Symbolic Formula*	*Input Voltage for 0–5V Range*
-32768	0V	0.0000V
-32767	1 LSB (V_{FS} / 65536)	0.000076V
...	...	...
-1	V_{FS} / 2 - 1 LSB	2.4999V
0	V_{FS} / 2	2.5000V
1	V_{FS} / 2 + 1 LSB	2.5001V
...	...	...
32767	V_{FS} - 1 LSB	4.9999V

15. A/D SCAN, INTERRUPT AND FIFO OPERATION

The control bits SCANEN (scan enable) and AINTE (A/D interrupt enable) in conjunction with the FIFO determine the behavior of the board during A/D conversions and interrupts.

At the end of an AD conversion, the 16-bit A/D data is latched into the 8-bit FIFO in an interleaved fashion: first LSB, then MSB. A/D Data is read out of the FIFO with 2 read operations, first Base + 0 (LSB) and then Base + 1 (MSB).

When SCANEN = 1, each time an A/D trigger occurs, the board will perform an A/D conversion on all channels in the channel range programmed in Base + 2. When SCANEN = 0, each time an A/D trigger occurs, the board will perform a single A/D conversion and then advance to the next channel and wait for the next trigger.

During interrupt operation (AINTE = 1), the FIFO will fill up with data until it reaches the threshold programmed in the FIFO threshold register, and then the interrupt request will occur. If AINTE = 0, the FIFO threshold is ignored and the FIFO continues to fill up.

If the FIFO reaches its limit of 48 samples, then the next time an A/D conversion occurs the Overflow flag OVF will be set. In this case the FIFO will not accept any more data, and its contents will be preserved and may be read out. In order to clear the overflow condition, the program must reset the FIFO by writing to the FIFORST bit in Base + 1, or a hardware reset must occur.

In Scan mode (SCANEN = 1), the FIFO threshold should be set to a number at least equal to the scan size and in all cases equal to an integral number of scans. For example if the scan size is 8 channels, the FIFO threshold should be set to 8, 16, 24, 32, 40, or 48, but not less than 8. This way the interrupt will occur at the end of the scan, and the interrupt routine can read in a complete scan or set of scans each time it runs.

In non-scan mode (SCANEN = 0), the FIFO threshold should be set to a level that minimizes the interrupt rate but leaves enough time for the interrupt routine to respond before the next A/D conversion occurs. Remember that no data is available until the interrupt occurs, so if the rate is slow the delay to receive A/D data may be long. Therefore for slow sample rates the FIFO threshold should be small. If the sample rate is high, the FIFO threshold should be high to reduce the interrupt rate. However remember that the remaining space in the FIFO determines the time the interrupt routine has to respond to the interrupt request. If the FIFO threshold is too high, the FIFO may overflow before the interrupt routine responds. A good rule of thumb is to limit the interrupt rate to no more than 1,000-2,000 per second in Windows and Linux or 10,000 per second in DOS. Experimentation may be necessary to determine the optimum FIFO threshold for each application.

The table on the next page describes the board's behavior for each of the 4 possible cases of AINTE and SCANEN. The given interrupt software behavior describes the operation of the Diamond Systems Universal Driver software. If you write your own software or interrupt routine you should conform to the described behavior for optimum results.

The following table describes the register settings for the A/D operating modes. (LOW and HIGH channels referenced in the table are the 4-bit channel numbers in Base+2.)

AINTE Base+4, bit 0	*SCANE Base+2, bit 1*	*Operation*
0	0	Single A/D conversions are triggered by write to B+0. STS stays high during the A/D conversion. No interrupt occurs. The user program monitors STS (Base+3, bit 7) and reads A/D data when STS goes low.
0	1	A/D scans are triggered by write to B+0. All channels between LOW and HIGH are sampled. STS stays high during the entire scan (multiple A/D conversions). No interrupt occurs. The user program monitors STS (Base+3, bit 7) and reads A/D data when STS goes low.
1	0	Single A/D conversions are triggered by the source selected with ADCLK (Base+4, bit 4). STS stays high during the A/D conversion. A/D interrupt occurs when the FIFO reaches its programmed threshold. The interrupt routine reads the number of samples equal to the FIFO threshold (Base+5, bits 0-5).
1	1	A/D scans are triggered by the source selected with ADCLK (Base+4, bit 4). STS stays high during the entire scan (multiple A/D conversions). A/D interrupt occurs when the FIFO reaches its programmed threshold. The interrupt routine reads the number of samples equal to the FIFO threshold (Base+5, bits 0-5).

16. DIGITAL-TO-ANALOG OUTPUT RANGES AND RESOLUTION

16.1 Description

Hercules III uses a 4-channel 12-bit D/A converter (DAC) to provide four analog outputs. A 12-bit DAC can generate output voltages with the precision of a 12-bit binary number. The maximum value of a 12-bit binary number is 2^{12} - 1, or 4095, so the full range of numerical values that the DACs support is 0 - 4095. The value 0 always corresponds to the lowest voltage in the output range, and the value 4095 always corresponds to the highest voltage minus 1 LSB. The theoretical top end of the range corresponds to an output code of 4096 which is impossible to achieve.

Note: In this manual, the terms analog output, D/A, and DAC are all used interchangeably to mean the conversion of digital data originating from the Hercules III computer hardware to an analog signal terminating at an external source.

16.2 Resolution

The resolution is the smallest possible change in output voltage. For a 12-bit DAC the resolution is $1/(2^{12})$, or 1/4096, of the full-scale output range. This smallest change results from an increase or decrease of 1 in the D/A code, so this change is referred to as 1 least significant bit (1 LSB). The value of this LSB is calculated as follows.

1 LSB = Output voltage range / 4096

Example:

For, Output range = 0-10V,

Output voltage range = 10V – 0V = 10V

Therefore,

1 LSB = 10V / 4096 = 2.44mV

Example:

For, Output range = ±10V;

Output voltage range = 10V – (-10V) = 20V

Therefore,

1 LSB = 20V / 4096 = 4.88mV

16.3 Output Range Selection

The DACs can be configured for 0-10V or ±10V.Two parameters are configured:

- unipolar/bipolar mode
- power-up/reset clear mode.

In most cases, for unipolar mode configure the board to reset to zero scale, and for bipolar mode configure the board for reset to mid-scale. In each case, the DACs reset to 0V.

16.4 D/A Conversion Formulas and Tables

The formulas below explain how to convert between D/A codes and output voltages.

16.4.1 D/A Conversion Formulas for Unipolar Output Ranges

Output voltage = (D/A code / 4096) * Reference voltage

D/A code = (Output voltage / Reference voltage) * 4096

Example:

For,

Output range in unipolar mode = 0 – 10V,

and,

Full-scale range = 10V – 0V = 10V,

if,

Desired output voltage = 2.000V,

D/A code = 2.000V / 10V * 4096 = 819.2 => 819

Note: the output code is always an integer.

For the unipolar output range 0-10V, 1 LSB = 1/4096 * 10V = 2.44mV.

The following table illustrates the relationship between D/A code and output voltage for a unipolar output range (VREF = Reference voltage).

D/A Code	*Output Voltage Symbolic Formula*	*Output Voltage for 0-10V Range*
0	0V	0.0000V
1	1 LSB (V_{REF} / 4096)	0.0024V
...	...	...
2047	V_{REF} / 2 - 1 LSB	4.9976V
2048	V_{REF} / 2	5.0000V
2049	V_{REF} / 2 + 1 LSB	5.0024V
...	...	...
4095	V_{REF} - 1 LSB	9.9976V

16.4.2 D/A Conversion Formulas for Bipolar Output Ranges

Output voltage = ((D/A code – 2048) / 2048) * Output reference

D/A code = (Output voltage / Output reference) * 2048 + 2048

Example:

For,

Output range in bipolar mode = ±10V

and,

Full-scale range = 10V – (-10V) = 20V

if,

Desired output voltage = 2.000V

D/A code = 2V / 10V * 2048 + 2048 = 2457.6 => 2458

For the bipolar output range ±10V, 1 LSB = 1/4096 * 20V, or 4.88mV.

The following table illustrates the relationship between D/A code and output voltage for a bipolar output range (VREF = Reference voltage).

D/A Code	*Output Voltage Symbolic Formula*	*Output Voltage for ±10V Range*
0	$-V_{REF}$	-10.0000V
1	V_{REF} + 1 LSB	-9.9951V
...	...	...
2047	-1 LSB	-0.0049V
2048	0	0.0000V
2049	+1 LSB	0.0049V
...	...	...
4095	V_{REF} - 1 LSB	9.9951V

17. GENERATING AN ANALOG OUTPUT

There are three steps involved in performing a D/A conversion, or generating an analog output. Each step is described in more detail, below. The descriptions use direct programming instead of driver software.

Compute the D/A code for the desired output voltage.

12. Write the value to the selected output channel.
13. Wait for the D/A to update.

17.1 Compute the D/A Code for the Desired Output Voltage

Use the formulas in the preceding section to compute the D/A code required to generate the desired voltage.

> **Note:** The DAC cannot generate the actual full-scale reference voltage; to do so would require an output code of 4096, which is not possible with a 12-bit number. The maximum output value is 4095. Therefore, the maximum possible output voltage is always 1 LSB less than the full-scale reference voltage.

17.2 Write the Value to the Selected Output Channel Registers

Use the following formulas to compute the LSB and MSB values.

LSB = D/A Code & 255 ;keep only the low 8 bits

MSB = int(D/A code / 256) ;strip off low 8 bits, keep 4 high bits

Example:

For,

Output code = 1776

Compute,

LSB = 1776 & 255 = 240 (0xF0)

and

MSB = int(1776 / 256) = int(6.9375) = 6

The LSB is an 8-bit number in the range 0-255. The MSB is a 4-bit number in the range 0-15.

The MSB is always rounded *down*. The truncated portion is accounted for by the LSB.

Write these values to the selected channel. The LSB is written to Base+6. The MSB and channel number are written to Base+7 (MSB = bits 0-3, channel number,0-3 = bits 6-7).

```
outp(Base+6, LSB);
outp(Base+7, MSB + channel << 6);
```

17.3 Wait for the D/A to Update

Writing the MSB and channel number to Base+7 starts the D/A update process for the selected channel. The update process requires approximately 30 microseconds to transmit the data serially to the D/A chip and update the D/A circuit in the chip. During this period, no attempt should be made to write to any other channel in the D/A through addresses Base+6 or Base+7.

The status bit DACBUSY (Base+3, bit 4) indicates if the D/A is busy updating (1) or idle (0). After writing to the D/A, monitor DACBUSY until it is zero before continuing with the next D/A operation.

18. ANALOG CIRCUIT CALIBRATION

The Hercules III data acquisition circuit contains an advanced autocalibration circuit that can maintain the accuracy of both A/D and D/A circuits to within the specified tolerances regardless of time and temperature. Autocalibration is supported in the Diamond Systems Universal Driver software included with the board.

The autocalibration circuit uses an ultra-stable +5V reference voltage IC as the source for its calibration. Both A/D and D/A circuits are calibrated in the analog domain by using a series of 8-bit "TrimDACs" to adjust the offset and gain settings of the circuits. The data values driving the DACs are stored in an EEPROM and are loaded automatically each time the board powers up.

During the autocalibration process, the board will measure the on-board reference and calibrate the A/D circuit by adjusting the TrimDACs to achieve the best accuracy. Once the A/D circuit is calibrated, the D/A circuit is calibrated by routing the D/A outputs into the A/D converter and adjusting them as well. The new calibration values for the TrimDACs are stored back into the EEPROM so they can be automatically recalled thereafter.

A unique feature of Diamond's autocalibration process is that each analog input range is individually calibrated for optimum performance. Analog amplifier circuits with 16-bit accuracy exhibit gain and offset errors that vary depending on the gain setting. The settings that work best for one range may not be sufficient to calibrate another. If a circuit is calibrated for maximum accuracy in a particular input range, such as +/-5V, changing the input range to +/-10V or 0-2.5V may introduce errors that exceed the resolution of a 16-bit measurement and will require calibration again.

To counteract this phenomenon, Diamond's autocalibration circuit provides for a separate complete set of calibration settings for each analog input range. During the autocalibration process, each range is calibrated one at a time, and its set of calibration settings is stored in a separate area of the EEPROM's memory. One of these ranges is identified as the "boot range", and this range's calibration values are the ones that are automatically recalled during power-up. You have the option of specifying the boot range, which should be chosen as the range most commonly used in your application. When you change the input range, you have the option of loading the calibration values for the new input range to maintain optimum accuracy of your measurements.

The autocalibration process is triggered with a single function call in the Diamond Universal Driver software. The process takes about 10-20 seconds to calibrate the complete set of analog input ranges and about the same time for the D/A circuit. Autocalibration can easily be incorporated into your application program, so that you can calibrate the data acquisition circuit as often as necessary while your system is running.

19. DIGITAL I/O OPERATION

Hercules III contains 40 digital I/O lines organized as five 8-bit I/O ports: Port A-E. The direction of each port is programmable. Port E is also used for the PWM outputs. The port data are accessed at registers Base+8 through Base+10, and the port direction register is located at Base+11.

Base +	***7***	***6***	***5***	***4***	***3***	***2***	***1***	***0***
8	PA7	PA6	PA5	PA4	PA3	PA2	PA1	PA0
9	PB7	PB6	PB5	PB4	PB3	PB2	PB1	PB0
10	PC7	PC6	PC5	PC4	PC3	PC2	PC1	PC0
11	DIOCTR	-	-	DIRA	DIRCH	-	DIRB	DIRCL

The digital I/O lines are located on I/O header J8. The lines are 3.3V and 5V logic compatible. Each output is capable of supplying –8mA in logic 1 state and +12mA in logic 0 state.

DIRA, DIRB, DIRCH, and DIRCL control the direction of ports A, B, C4-7 and C0-3. A direction value of 0 means output and 1 means input. All ports power up to input mode and the output registers are cleared to zero. When a port direction is changed to output, its output register is cleared to zero. When a port is in output mode, its value can be read back.

DIOCTR is used to control the function of lines C7-C4 on the I/O connector. When DIOCTR = 1, the lines are port C7-C4. When DIOCTR = 0, the lines are used for the counter/timer.

Pin Number	***DIOCTR = 1***	***DIOCTR = 0***	***Pin direction for DIOCTR = 0***
40	C4	Gate0	Input
37	C5	Gate1	Input
	C6	Clk1	Input
	C7	Out0	Output

20. COUNTER/TIMER OPERATION

Hercules III contains two counter/timers that provide various timing functions on the board for A/D timing and user functions. These counters are controlled with registers in the on-board data acquisition controller FPGA.

20.1 Counter 0 – A/D Sample Control

Counter 0 is a 24-bit, "divide-by-n" counter used for controlling A/D sampling. The counter has a clock input, a gate input, and an output. The input is a 10MHz or 1MHz clock provided on the board and selected with bit CKFRQ0 in register Base+4, bit 5. The gate is an optional signal that can be input on pin 21 of I/O header J14 when DIOCTR (Base+11, bit 7) is 1. If this signal is not used, the counter runs freely. The output is a positive pulse whose frequency is equal to the input clock divided by the 24-bit divisor programmed into the counter. The output appears on pin 24 of the I/O header when DIOCTR is 1.

The counter operates by counting down from the programmed divisor value. When the counter reaches zero, it outputs a positive-going pulse equal to one input clock period (100ns or 1µs, depending on the input clock selected by CKFRQ0). The counter then reloads to the initial load value and repeats the process, indefinitely.

The output frequency can range from 5MHz (10MHz clock, divisor = 2) to 0.06Hz (1MHz clock divided by 16,777,215, or 224-1). The output is fed into the A/D timing circuit and can be selected to trigger A/D conversions when Base+4 register bits AINTE is 1 and ADCLK is 0. Using the control register at Base+15, the counter can be loaded, cleared, enabled and disabled. The optional gate can be enabled and disabled, and the counter value can be latched for reading.

20.2 Counter 1 – Counting/Totalizing Functions

Counter 1 is similar to Counter 0 except that it is a 16-bit counter. Counter 1 also has an input, a gate and an output. These signals may be user-provided on the I/O header when DIOCTR is 0, or the input may come from the on-board clock generator. When the on-board clock generator is used, the clock frequency is either 10MHz or 100KHz, as determined by control Base+4 register bit CKFRQ1.

The output is a positive-going pulse that appears on pin 26 of the I/O header. The output pulse occurs when the counter reaches zero. When the counter reaches zero, it reloads and restarts on the next clock pulse. The output stays high for the entire time the counter is at zero; i.e., from the input pulse that causes the counter to reach zero until the input pulse that causes the counter to reload.

When DIOCTR is 0, Counter 1 operates as follows.

- It counts positive edges of the signal on pin 23 on the I/O header.
- The gate is provided on pin 22. If the signal is high, the counter counts. If the signal is low, the counter holds its value and ignore input pulses. This pin has a pull-up so the counter can operate without any external gate signal.

  NOTE: When counting external pulses, Counter 1 only updates its read register every fourth pulse. This behavior is due to the synchronous design of the counter having to contend with the asynchronous input pulses. The count register contents are correct on the fourth pulse but remain static until four additional pulses occur on the input.

When DIOCTR is 1, Counter 1 operates as follows.

The counter takes its input from the on-board clock generator based on the value of the Base+4 register CKFRQ1 bit. There is no gating and the counter runs continuously.

Counter 1 may be used as either a pulse generator or a totalizer/counter. In pulse generator mode, the output signal on pin 26 is of interest. In totalizer/counter mode, the counter value is of interest and may be read by first latching the value and then reading it. The width of the pulse is equal to the time period of the selected counters clock source.

20.3 Command Sequences

Diamond Systems provides driver software to control the counter/timers on Hercules III. The information in this section is intended as a guide for programmers writing their own code, instead of using the driver, and to give a better understanding of the counter/timer operation.

The counter control register is located at I/O address base+15.

20.3.1 Load and Enable (Run) a Counter Sequence

14. Write the data to the counter. For counter 0, three bytes are required to load a 24-bit value. For counter 1, two bytes are needed for a 16-bit value. The value is an unsigned integer.

    Break the load value into 3 bytes: low, middle, and high, (Two bytes for Counter 1) and write the bytes to the data registers in any sequence.

    Counter 0:
    ```
    outp(base+12,low);
    outp(base+13,middle);
    outp(base+14,high);
    ```
    Counter 1:
    ```
    outp(base+12,low);
    outp(base+13,high);
    ```

15. Load the counter.

    Counter 0:
    ```
    outp(base+15,0x02);
    ```
    Counter 1:
    ```
    outp(base+15,0x82);
    ```

16. Enable the gate if desired. The gating may be enabled or disabled at any time. When gating is disabled, the counter counts all incoming edges. When gating is enabled, if the gate is high the counter counts all incoming edges and, if the gate is low, the counter ignores incoming clock edges.

    Counter 0:
    ```
    outp(base+15,0x10);
    ```
    Counter 1:
    ```
    outp(base+15,0x90);
    ```

17. Enable the counter. A counter may be enabled or disabled at any time. If disabled, the counter ignores incoming clock edges.

    Counter 0:
    ```
    outp(base+15,0x04);
    ```
    Counter 1:
    ```
    outp(base+15,0x84);
    ```

20.3.2 Read a Counter Sequence

18. Latch the counter.

Counter 0:
```
outp(base+15,0x40);
```
Counter 1:
```
outp(base+15,0xC0);
```

19. Read the data.

    The value is returned in 3 bytes, low, middle, and high (2 bytes for counter 1).

Counter 0:
```
low=inp(base+12);
middle=inp(base+13);
high=inp(base+14);
```
Counter 1:
```
low=inp(base+12);
high=inp(base+13);
```

20. Assemble the bytes into the complete counter value.

Counter 0:
```
val = high * 2^16 + middle * 2^8 + low;
```
Counter 1:
```
val = high * 2^8 + low;
```

20.3.3 Disabling the Counter Gate Command

- Disabling the counter gate, as shown below, causes the counter to run continuously.

Counter 0:

```
outp(base+15,0x20);
```

Counter 1:

```
outp(base+15,0xA0);
```

20.3.4 Clearing a Counter Sequence

Clear a counter to restart an operation. Normally, a counter is only cleared after stopping (disabling) and reading the counter. If you clear a counter while it is enabled, it continues to count incoming pulses so the counter value may not remain at zero.

21. Stop (disable) the counter.

Counter 0:

```
outp(base+15,0x08);
```

Counter 1:

```
outp(base+15,0x88);
```

22. Read the data (optional).

    The value is returned in 3 bytes, low, middle, and high (2 bytes for counter 1).

Counter 0:

```
low=inp(base+12);
middle=inp(base+13);
high=inp(base+14);
```

Counter 1:

```
low=inp(base+12);
high=inp(base+13);
```

23. Clear the counter.

Counter 0:

```
outp(base+15,0x01);
```

Counter 1:

```
outp(base+15,0x81);
```

21. WATCHDOG TIMER PROGRAMMING

Hercules III contains a watchdog timer circuit consisting of one programmable timer. The input to the circuit is WDI and the output is WDO, which appear on connector J8. WDI may be triggered in hardware or in software. A special "early" version of WDO may be output on the WDO pin. When this signal is connected to WDI, the watchdog circuit is retriggered automatically.

The watchdog timer duration is user-programmable. When WDT is triggered, it begins to count down. Upon reaching zero, it generates a user-selectable combination of the following events.

- System management interrupt
- Hardware reset

The watchdog timer circuit is programmed using I/O registers located at address 0x25C. Detailed programming information is described, below. The Hercules III watchdog timer is supported in the DSC Universal Driver software version 5.7 and later.

21.1 Watchdog Timer Register Details

The registers in the following table are used to program the watchdog timer.

I/O Address	*Write Function*	*Read Function*
0x25C	WDT trigger	None, write-only
0x25D	WDT, counter	None, write-only
0x25E	Watchdog control	Readback
0x25F	Chip select enable/disable	Readback the last bits written

In the tables, below, a blank bit (-) indicates the bit is unused. A blank bit in the read registers reads back as 0 or 1, unknown state.

I/O Address: 0x25C (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	-			WDTRIG	-			

WDTRIG Writing a 1 triggers an immediate software reload of the watchdog timer.

I/O Address: 0x25D (Write)

Bit:	7	6	5	4	3	2	1	0
Name:	WDT3	WDT2	WDT1	WDT0	-			

WDT4-7 Writing to bits WDT4-7 loads the watchdog timer with the 4-bit counter value. Use this register to set the countdown period. Each tick is 145ms, so the period range is 145ms to 2.175 seconds (1 to 15).

I/O Address: 0x25E (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	WDIEN	WDOEN	WDSMI	WDEDGE	-			

WDIEN 0 = Disable edges on the WDI pin, retriggering watchdog timer.

1 = Enable edges on the WDI pin retriggering watchdog timer.

WDOEN 0 = Disable edge on WDO pin when watchdog timer reaches 1.

1 = Enable edge on WDO pin when watchdog timer reaches 1.

WDSMI 0 = Disable system management interrupt signal when watchdog timer reaches 0.

1 = Enable system management interrupt signal when watchdog timer reaches 0.

WDEDGE 0 = Falling edge on WDI retriggers watchdog timer, when WDIEN = 1.

1 = Rising edge on WDI retriggers watchdog timer, when WDIEN = 1.

I/O Address: 0x25F (Read/Write)

Bit:	7	6	5	4	3	2	1	0
Name:	COM4EN	COM3EN	FPGAEN	WDEN	-			

COM4EN COM4 chip select enable.

1 = Enable COM4-CS#.

0 = Disable COM4-CS#.

COM3EN COM3 chip select enable.

1 = Enable COM3-CS#.

0 = Disable COM3-CS#.

FPGAEN FPGA chip select enable.

1 = Enable FPGA-CS#.

0 = Disable FPGA-CS#.

WDEN Watchdog enable.

1 = Watchdog timer counter enable.

0 = Watchdog timer counter disable, WDO disable, WDI disable, CPURST# disable, EXTSMI# disable.

The CPLD initializes all values to zero on power up, and the BIOS enables each resource based on BIOS settings.

22. DATA ACQUISITION SPECIFICATIONS

22.1 Analog Inputs (data acquisition units only)

- Number of inputs: 16 differential or 32 single-ended (user selectable)
- A/D resolution: 16 bits (1/65,536 of full scale)
- Input ranges,
- Bipolar: ±10V, ±5V, ±2.5V, ±1.25V
- Unipolar: 0-10V, 0-5V, 0-2.5V
- Input bias current: 50nA max
- Maximum input voltage: ±10V for linear operation
- Over-voltage protection: ±35V on any analog input without damage
- Nonlinearity: ±2LSB, no missing codes
- Drift: 10PPM/^{o}C typical
- Conversion rate: 100,000 samples per second max
- Conversion trigger: software trigger, internal pacer clock, or external TTL signal
- FIFO: 2048 samples, programmable interrupt threshold

22.2 Analog Outputs (data acquisition units only)

- No. of outputs: 4
- D/A resolution: 12 bits (1/4096 of full scale)
- Output ranges,
- Unipolar: 0-10V or user-programmable
- Bipolar: ±10V or user-programmable
- Output current: ±5mA max per channel
- Settling time: 4µS max to ±1/2 LSB
- Relative accuracy: ±1 LSB
- Nonlinearity: ±1 LSB, monotonic

22.3 Digital I/O

- No. of lines: 40
- Compatibility: 3.3V and 5V logic compatible
- Input voltage: Logic 0: -0.5V min, 0.8V max; Logic 1: 2.0V min, 5.5V max
- Input current: ±1µA max
- Output voltage: Logic 0: 0.0V min, 0.4V max; Logic 1: 2.4V min, 3.3V max
- Output current: Logic 0: 12mA max; Logic 1: -8mA max
- I/O capacitance: 10pF max

22.4 Counter/Timers (data acquisition units only)

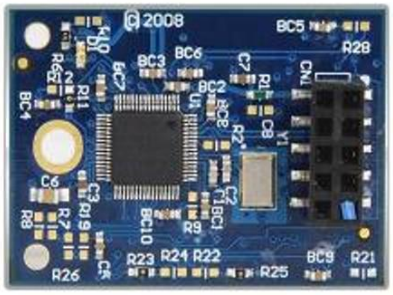
- A/D pacer clock: 24-bit down counter
- Clock source: 10MHz, 1MHz or external signal
- General purpose: 16-bit down counter
- Clock source: 10MHz, 100KHz or external signal

23. MSATA FLASHDISK MODULE

Hercules III is designed to accommodate an optional solid-state mSATA flashdisk module using either MLC (FDMM-xxx-XT models) or SLC (FDMS-xxx-XT models) technology. The modules contain from 8GB to 64GB of solid-state non-volatile memory that operates like a disk drive without requiring additional driver software support.

The flashdisk module installs directly on the mSATA flashdisk connector, J35, and is held down with a spacer and two screws onto a mounting hole on the board.

Model	*Capacity*
FDMM-64G-XT	64GB
FDMM-32G-XT	32GB
FDMM-16G-XT	16GB
FDMM-8G-XT	8GB
FDMS-64G-XT	64GB
FDMS-32G-XT	32GB
FDMS-16G-XT	16GB
FDMS-8G-XT	8GB



FlashDisk Module

24. SPECIFICATIONS

24.1 CPU

- Processor: Intel Atom E680T CPU
- Speed: 1.6GHz
- Power consumption: 13.8W nominal; 20W maximum
- Cooling: Heat sink with fan
- Operating Temperature: -40ºC to +85ºC
- Chipset: Intel Topcliff
- On-board DRAM memory: 1GB or 2GB
- Bus interface: PC/104-*Plus* (ISA + PCI)
- Display type: CRT and/or 18-bit dual channel LVDS flat panel
- CRT resolution: 1600 x 1200
- Flat Panel Resolution : UXGA 1600 x 1200
- USB ports: 5 USB 2.0; 1 USB 2.0 device port
- 1 mSATA flashdisk socket supports up to 64GB
- Serial ports: 4 RS-232/485; 2 RS-232
- Networking: dual Gigabit Ethernet
- Mass storage interfaces: 1 SATA port; 1 mSATA interface
- 1 CANbus 2.0 port
- Keyboard/mouse: PS/2
- Audio: HD audio with Realtek ALC262 CODEC
- Expansion sockets: PCIe MiniCard full sized socket; GPS receiver socket

24.2 Data Acquisition Circuitry

- Analog inputs: 32 single-ended, 16 differential; user selectable
- A/D resolution: 16 bits
- Bipolar ranges: ±10V, ±5V, ±2.5V, ±1.25V
- Sample rate: 250KHz maximum total
- Unipolar ranges: 0-10V, 0-5V, 0-2.5V, 0-1.25V
- Input bias current: 100pA max
- Protection: ±35V on any analog input without damage
- Input Impedance: 10^13 ohms
- Relative accuracy: ±2 LSB after autocalibration
- Nonlinearity: ±3LSB, no missing codes
- Conversion rate: 100,000 samples/sec. max
- On-board FIFO: 2048 samples, programmable threshold
- A/D and D/A Calibration: Automatic using on-board microcontroller and temperature sensor
- Analog Outputs: 4, 12-bit resolution
- Output ranges: ±5V, ±10V, 0-5V, 0-10V
- Output current: ±5mA max per channel
- Settling time: 7µS max to 0.01%
- Relative accuracy: ±1 LSB
- Nonlinearity: ±1 LSB, monotonic

- Reset: Reset to zero-scale or mid-scale (jumper selectable)
- Waveform buffer: 1,024 samples
- Digital I/O lines: 40 programmable direction in 8-bit ports
- Input voltage: Logic 0: 0.0V min, 0.8V; max Logic 1: 2.0V min, 5.0V max
- Input current: ±1µA max
- Output voltage: Logic 0: 0.0V min, 0.33V; max Logic 1: 2.4V min, 5.0V max
- Output current: Logic 0: 64mA max per line Logic 1: -15mA max per line
- A/D Pacer clock: 24-bit down counter (source: 10MHz, 1MHz or external signal)
- General purpose: 16-bit down counter (source: 10MHz, 100KHz or external signal)
- 4 pulse width modulators

24.3 Power Supply

- Input Voltage: +7-40V DC/DC power supply
- Output Power: 55W
- Available Power: 35W (up to 20W consumed by SBC)

24.4 General

- Shock: MIL-STD-202G, Method 213B compliant
- Vibration: MIL-STD-202G, Method 214A compliant
- Dimensions: 5.75 x 8.0 in. (106 x 114mm)
- Weight: 10.1oz.(286g) without heatsink